

# THE GATALOG PRESENTS...



## EXTENDED-LENGTH ECM BARRELS

A FORK OF THE ECM V2 & V3 PROCESSES BY RSMITH28

Document Version 1.0.1

Document by: RSmith28

For all your prior research and publications in electrochemical machining, a special thank you to:

**Cskeju**

**JeffRod**

**IvanTheTroll**

**JStark1809**

**ImmortalRevolt**

And anyone else I missed!

This document is intended to instruct an individual through the process of privately manufacturing a rifled barrel by electrochemical machining (ECM). Compared to previously published documents on the subject, this one aims to improve upon formatting and organization and contains changes required for creating extended-length barrels using an FGC-style barrel retainer.

The contents of this document are strongly inspired by the ECM tutorials published with both generations of the FGC-9 and the Partisan 9, and some parts are copied verbatim with written permission from IvanTheTroll. Most of the credit for this document goes to their respective authors.

**This document was originally published to accompany the Urutau documentation, but we chose to compile it separately, as its contents will likely benefit more than just the Urutau. If you have not already, we recommend reviewing American Legal Warning and OpSec & Obfuscation, available in the Urutau documentation, before proceeding.**

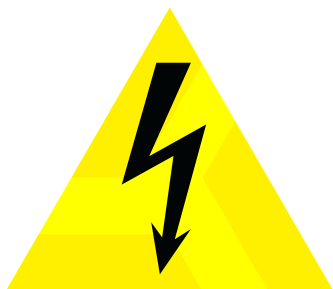
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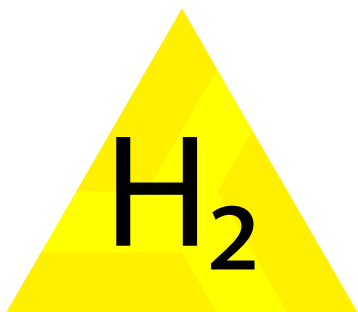
# WARNINGS



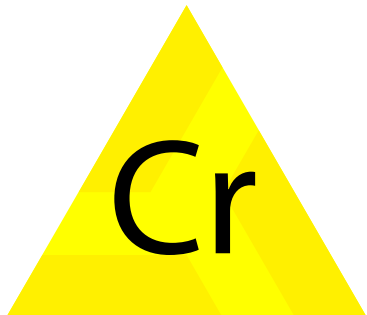
Let us be very clear. You are about to engage in an electrochemical experiment authored and published by strangers on the internet. While we hope this is obvious, please understand that we make absolutely no promises of success or safety in this document, its associated CAD files, or any final projects its use is intended for.



If you choose to complete the boring process with an arc welder, please understand that you will work with potentially lethal amounts of electrical current. Before physically handling your toolpiece or workpiece, ensure that the arc welder is completely de-energized and will not become re-energized.



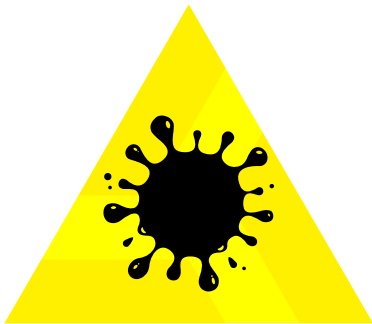
The electrolysis that occurs when cutting will create hydrogen gas. This will build in the air occupying an unventilated area, creating a potential fire and explosion hazard. Please conduct all cutting procedures in a well-ventilated area. If you use an arc welder, you will want to complete at least that stage of the process outdoors.



We strongly caution against ingestion or skin contact with the byproducts, or sludge, created in this process. From testing, we found no evidence of hexavalent chromium in the sludge, but further verification of this conclusion is encouraged.



We are not lawyers, and no part of this document is to be construed as legal advice. For Americans, please be reminded that rifled barrels applied to firearms designed to fire from the shoulder must generally meet or exceed a length of 16". For those outside the United States of America, please understand that by following this guide, you may be creating contraband and crossing the point of no return. Please check your jurisdiction's laws to determine if that is a risk you are willing to take.



The byproducts of the processes described in this document will stain surfaces. These stains are practically impossible to remove. (Trust me. I tried.) When completing any processes involving liquid, please wear clothing that is unimportant or disposable. Ideally, complete these process in an area with floors and walls that can get dirty. If you do not have access to such a place, use a tarp to protect the floor and any nearby walls. If you complete these processes in a bathtub, you can minimize staining by filling the tub with about an inch of water.



When using brake cleaner or an aerosol-canned lubricant and cotton patches, we recommend spraying the liquid onto a cotton patch and then inserting the patch into the barrel. Spraying the liquid directly into the barrel is an option, but please protect your eyes if you do. If you miss, liquid may hit the flat surface of the barrel and spray outward, potentially contacting your eyes. (Do not ask how I know this.)



Please remember that it is our shared responsibility to be safe with firearms and to show the world there is a peaceful way to own them. Please take time to learn the basic and advanced rules of firearm safety. If it does not implicate you, take time to receive professional firearm training and share the hobby with everyone interested. If you are met with scorn or hostility for expressing interest in this hobby, remember that those most afraid of firearms are often those who have no experience with them in the first place.

# KEY WORDS & DEFINITIONS

- **Electrochemical Machining (ECM):** Process of cutting metal. Review the ECM Fundamentals section for more details.
- **Reservoir:** Container for holding liquid.
- **Electrolyte:** Liquid that can conduct electricity. For the process described in this document, this is the saltwater.
- **Sludge:** Byproduct of the electrochemical machining process. A nasty mixture of metal ions, oxidized metals, trapped oxygen and hydrogen gas, and electrolyte.
- **Barrel Stock:** Unprocessed hydraulic tube you will make a barrel out of.
- **Barrel:** Part of a gun. Review the Barrel Fundamentals section for more details. For the purposes of this document, we will start referring to the barrel stock as a barrel when the ECM process begins.
- **Bore:** Broad term to describe the inside of a tube or barrel.
- **Boring:** ECM process to increase the inner diameter of the barrel.
- **Rifling:** Helical pattern of grooves inside the barrel which impart spin to a projectile for increased stability in flight.
- **Rifling (Cutting):** ECM process to cut rifling grooves inside the barrel.
- **Hill:** In polygonal rifling, lands are referred to as hills. Hill-to-hill measurement should be the same as the bore diameter. For 9mm projectiles for example, this document prescribes a hill-to-hill measurement of 8.82mm.
- **Valley:** In polygonal rifling, grooves are referred to as valleys. The valley-to-valley distance is slightly variable, but we default it to 9.01mm. It is usually at or slightly over the diameter of the projectile.
- **Chamber:** Short section of the barrel which seats cartridges and contains the explosion upon detonation.
- **Throat:** Transition area between the chamber and rifling. This keeps the projectile from crashing into the rifling upon chambering.

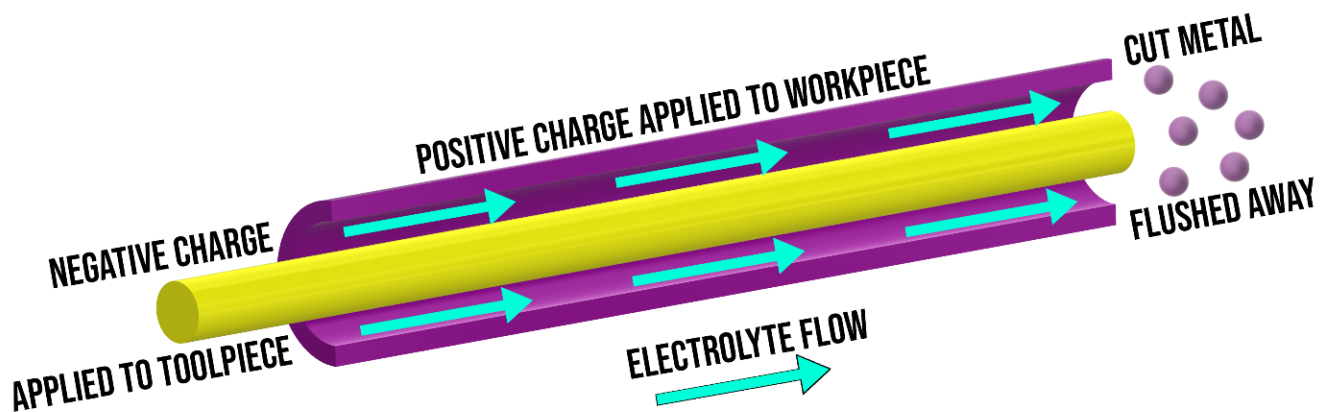
- **Throat Cutting & Chamber Cutting:** ECM process to add a throat and chamber to the barrel.
- **Toolpiece or Cathode:** Piece which is responsible for cutting and is negatively charged. This will be your boring rod, rifling mandrel, and throating/chambering rod.
- **Workpiece or Anode:** Piece which is being cut and is positively charged. This will be your barrel.
- **Insert Fitting:** Piece which connects a hose to another object.
- **Suction Side:** End of a pump assembly that sucks in fluid from the reservoir.
- **Pressure Side:** End of the pump assembly that pumps fluid out and into the barrel.
- **Bullet:** Metal projectile, usually lead jacketed in copper, lead with copper electroplating, or lead with a powder-coated paint job, that is projected from the barrel at a high velocity.
- **Primer:** Cup with a percussion-sensitive compound. Used to start the chemical reaction that sets off the gun.
- **Propellant:** Chemical compound which propels the bullet down and out the barrel. Modern propellants are generally a smokeless powder, not to be confused with black powder.
- **Casing:** Piece of metal which holds the bullet, primer, and propellant together until it is ready for use. The casing is typically made of brass, steel, or aluminum, and it is ejected from the firearm after firing along with the spent primer.
- **Case Head:** End of the casing where the primer is located.
- **Cartridge:** Assembly containing a casing, primer, propellant, and bullet.

# ELECTROCHEMICAL MACHINING

## FUNDAMENTALS

The purpose of this section is to provide contextual information on the instructions in this document. Reading and understanding this section is not required to follow the instructions, like how you do not need to know how an engine works in order to drive a car. However, we chose to include it for those seeking a deeper understanding of the underlying processes.

Electrochemical machining (ECM) is a non-traditional machining process which uses an electrolyte and electrical energy to remove material from a workpiece through controlled electrolysis reactions. An electrolyte solution, like saltwater, serves to conduct electricity between an anode and cathode, or workpiece and toolpiece, respectively. In the electrolysis of the saltwater, the anode undergoes a corrosion process due to an oxidation reaction that takes place. By controlling the placement of this oxidation and continuously flushing out the oxidized metal, one can remove material from the workpiece in a controlled, precise manner.

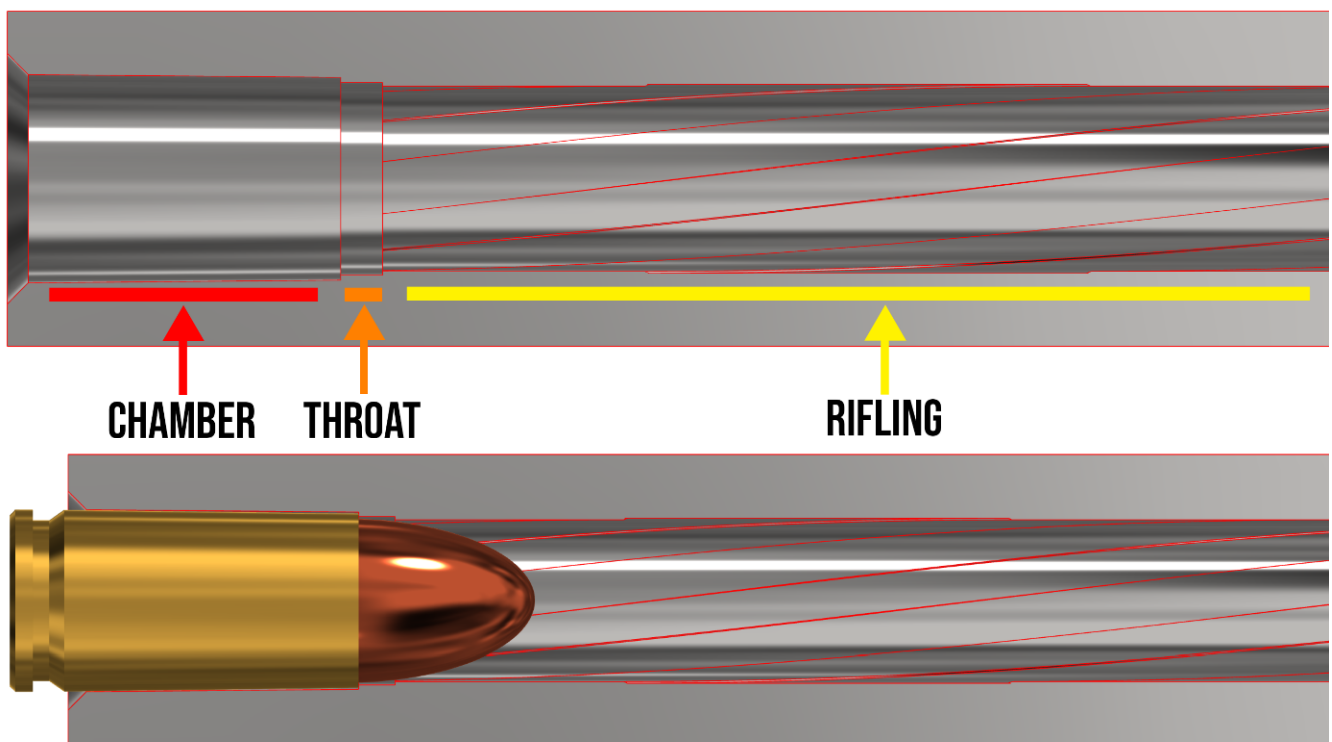


In this image, the center rod is cutting the inside of a round tube. The result of this configuration is that the inner diameter of the tube will increase over time.

If this sounds complicated, do not worry. To make a barrel, all you need to do is follow the instructions carefully.

# PARTS OF A BARREL

The privately manufacturable barrel described in this document is broken into three distinct sections, the rifling, throat, and chamber. The rifling occupies the majority of the barrel. It is a helical pattern of grooves designed to impart spin to a bullet for stability in flight. The chamber is a smooth, slightly tapered section which seats cartridges before they are fired. In a firearm like this barrel is intended for, a quality chamber should not retain the casing after going off. The throat is the section of the barrel that transitions between the chamber and throat. Between the chamber and throat, a “step” is needed to bring the cartridge to a hard stop, but the throat keeps the bullet from crashing into the rifling.



Again, if this sounds complex, please do not worry. All you need to do is follow the instructions carefully.

# MACHINERY, TOOLS, & MATERIALS

Possession and use of all of the following is mandatory unless specified otherwise.



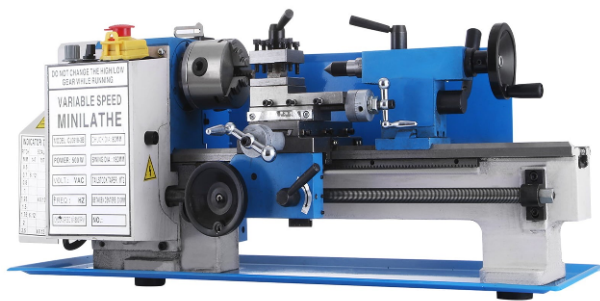
## 3D Printer & A Thorough Understanding of How to Use It

Use of a 3D printer takes time and mastery. Please make sure you can print an accurate calibration cube before engaging in this project.



## Chop Saw, Miter Saw, Angle Grinder, or Other Tool for Cutting Steel

Make sure you use an appropriate cutting disc for steel. Chop saws and miter saws are ideal because they make square cuts a lot easier.



## OPTIONAL – Lathe

When we say optional, we mean it. If you don't have one or don't have access to one, don't worry. If you do, however, you will find it helpful on a few steps.



### Handheld Drill

If you do not have access to a lathe, you are going to need this for a few steps. It does not matter if it is corded or cordless. Quality ones are expensive, but they are a worthwhile investment.



### Strongly Recommended – Arc Welder with Welding Clamps

This is useful to speed up the boring process, but if you can not acquire or use one safely, the boring process can be completed with the power supply below. If you are not able to complete the process outside, do not waste your money on this.



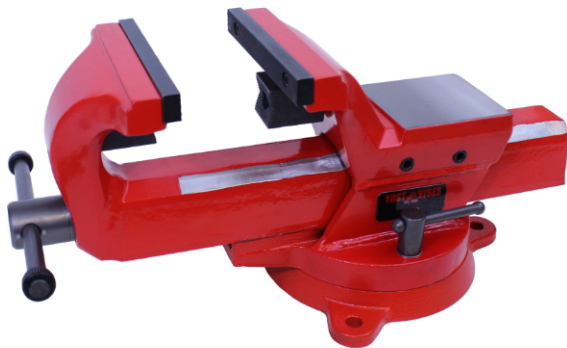
### 30V 10A (Maximum) Variable Power Supply

This will do most of the cutting if you are using an arc welder. If not, it will do all the cutting.



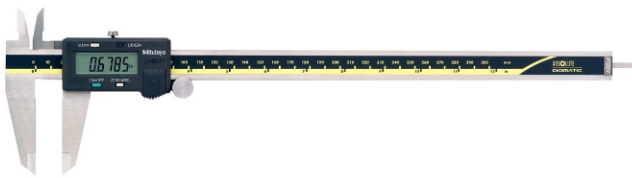
### **Vivosun 800GPH Submersible Pump**

This will pump electrolyte out of the reservoir and into the barrel. Upon testing, the flow rate was less than 800 gallons per hour, but it was still fast enough to meet expectations. You are welcome to substitute this with a pump of your choice.



### **Bench Vise Mounted to a Sturdy Surface**

If you are using a drill as a lathe-substitute, you will need this.



### **Caliper**

You will need this to take measurements. Quality ones are expensive, but a worthwhile investment.



### **Flat File Suited for Processing Steel**

You will need this to process the barrel and chambering rod.



### **Sandpaper Variety Pack**

You will need this for finer processing if your file is too coarse.



### **Dental Pick, Needle, or Other Pointy Tool**

You will need this for cleaning up your rifling mandrel.



### **Needle Nose Pliers**

You will need this when dressing the rifling mandrel with wires.



### **Knife with a Disposable Blade**

You will need this when cleaning up printed, plastic parts and when creating index marks in the barrel. You can use a different knife, but the tip of the blade may become slightly damaged.



### **Strongly Recommended – 10mm Flex Hone Brush**

While this is not a hard requirement, you will find this helpful for honing your chamber, enhancing the reliability of case extraction.



### **Flat-Head Screwdriver**

You will need this to tighten hose clamps.



### **Hose Clamps: 6mm-16mm ( $\frac{1}{4}$ "- $\frac{5}{8}$ ") & 16mm-25mm ( $\frac{5}{8}$ "-1")**

You will use these to secure vinyl hose to insert fittings, to secure plastic parts to your barrel, and to secure a wire to your barrel.

NOTE: These sizes are substitutable as long as they can secure hose to the insert fittings and plastic tools to the barrel.



### **$\frac{3}{4}$ " (19 or 20 mm) ID 1" (25mm or 26mm) OD Vinyl Hose**

You will need this to run electrolyte from the reservoir to the barrel. This is a wider diameter than previously published ECM guides recommend, but it is ideal for the Vivosun pump. If you use a different pump and insert fitting, you may need to substitute this item.



### **eSun PLA+**

You will need this to create 3D printed tools. This is substitutable with other quality filaments that you can print cleanly.

NOTE: For the best deal and quality, we recommend ordering eSun PLA+ from eSun's official online store. 10 packs of filament reels without a spool are the best deal, and reusable spools are cheap to print or purchase. Their website is also very generous with its coupon codes.

## 16mm OD 8mm ID Steel Hydraulic Pipe



**CAUTION: THIS IS A POTENTIALLY CONCERNING PURCHASE.** If you are unable to legally manufacture a firearm, your billing and shipping information could lead the authorities to investigate you. As of writing, we do not have a way of reliably making these in private, so please find ways to anonymize your billing and shipping information.

This is the metal tube that will eventually become your barrel. Currently, the best places to buy this are AliExpress and eBay. We recommend purchasing more than one of these in case of mistakes. If you are making an 11" barrel, it will need to be at least 30cm long. If you are making a 16" barrel, it will need to be at least 50cm long. (40cm is slightly less than 16".)



## 2" Round Cotton Patches & 1-1/8" Square Cotton Patches

You will need these to apply brake cleaner and oil to the inside of your barrel. The sizes specified are variable, but those are what worked for me.

If you are unable to legally own or manufacture a firearm and want to be extra cautious, cut these out of cotton fabric, paper towels, or unwanted clothing.



## Brake Cleaner

You will need this to clean out the inside of your barrel before beginning the ECM process, after every cutting operation, and before every measurement.



## Spray Rust Inhibitor

You will need this to preserve the inside and outside of your barrel after the process is complete. Ballistol is what I prefer due to its versatility, but for the extra paranoid, you may prefer something else like WD-40 Corrosion Inhibitor.



## Strongly Recommended – Epoxy Resin or Spray Sealant

You can use this to minimize leaking from the 3D printed fitting and/or fixture. Epoxy resin is messier to prepare but does a better job.



### **1/4" or 6mm Steel, Stainless Steel, or Copper Round Rod**

You will need this to create your boring rod and chambering rod. You will want this to be a few inches longer than your barrel, plus a few more inches for your chambering rod. This rod cannot have any coating applied to it.



### **1/4" or 6mm Drill Bit**

You will need this if you need to ream out any of your plastic tools. Choose the same diameter as the steel or copper rod you are using.



### **8X60mm Concrete Expander**

If you are using a handheld drill to process your barrel, you will need this to rotate it.



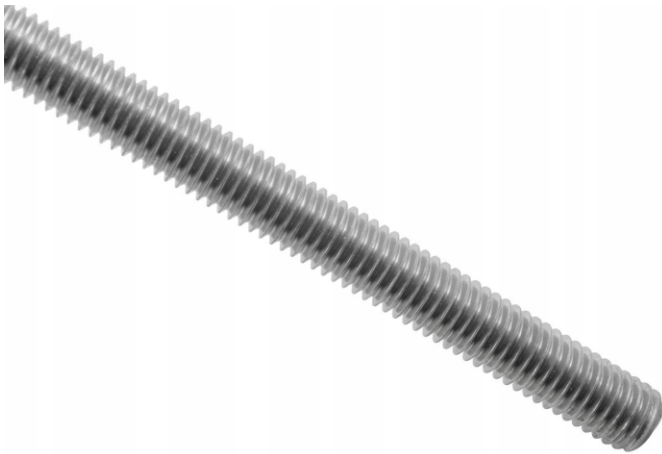
### **J-B Weld**

You will need this to make the rifling mandrel.



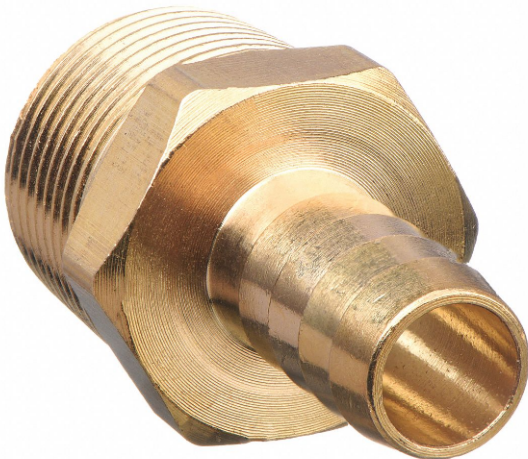
### **Bare 20 AWG (0.8mm) Copper Wire**

You will dress your rifling mandrel with this wire. It is important that it does not have any coating applied to it.



### **M2 Threaded Rod**

You will use this to add rigidity to your rifling mandrel.



### **Optional – 1/2" BSP or NPT Thread to 20mm or 3/4" Barb Insert Fitting**

If you do not want to buy this, the printed one works just fine. If you do, you will use this to interface the hose with the 3D printed fixture.



### **Non-Iodized Table Salt**

If you are making 3 gallons of electrolyte, you will need 75 grams. Keeping extra on hand is recommended ... and tasty.



### **3 Gallons of Water**

You will need this to make 3 gallons of electrolyte. If you use tap water, that is okay, but its additives may influence the cutting rate slightly. This is not an issue, but it something to be aware of.



### **5 Gallon Bucket**

This bucket will become your reservoir. If you have more than 3 gallons of electrolyte, you will want a bigger bucket.



### **14 AWG Insulated Wire**

When you are not using the arc welder, you will use this and a hose clamp to positively charge the barrel.

Make sure you also have the ability to strip the ends of the wire.



### **Banana Plug – Alligator Clip Wires**

When you are not using the arc welder, you will need these to connect the power supply to the barrel and toolpiece.



### **Camera Tripod**

When fully extended, you will find this helpful to position your barrel over the reservoir. Be aware that it will likely become stained by drops of electrolyte.



### 3 Separate DIN 705 16mm ID Shaft Collars

The OD should be 28mm and the width should be 12mm. You will mount these to your barrel in order to retain it in your firearm.



### DIN 916 M6 6mm-Long Set Screws

You may need these to secure the shaft collars to the barrel if the set screw it comes with protrudes from the shaft collar.



### Threadlocking Compound

You will need this to prevent the set screws on the shaft collars from coming loose.



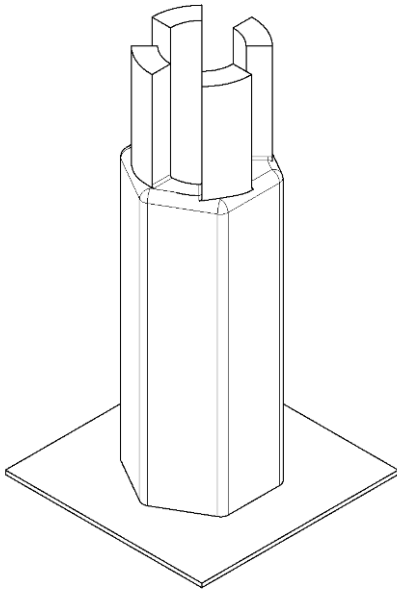
## Masking Tape

You will need this when making your chambering rod and when honing your chamber.

# 3D PRINTED PARTS

The following information is a list of general recommendations for the parts you will need to 3D print. For all parts, we recommend using eSun PLA+ or another quality filament at 100 percent infill. You know your 3D printer better than we do, so anything we do not specify is up to your best judgment.

## Image & Print Orientation

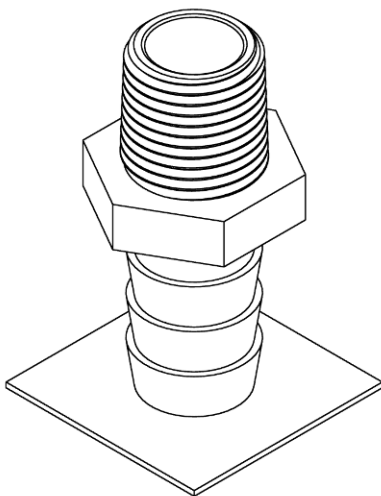
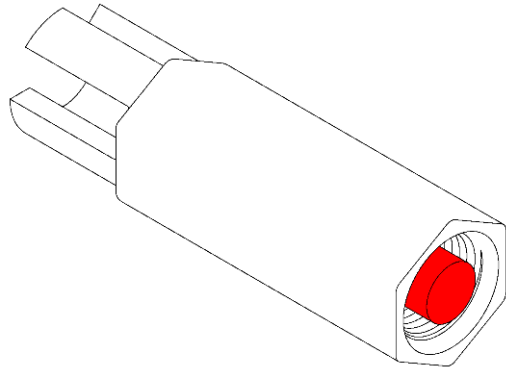


## Name & Description

### Fixture

Do not use support structures.

Do not remove the center peg, as depicted below.

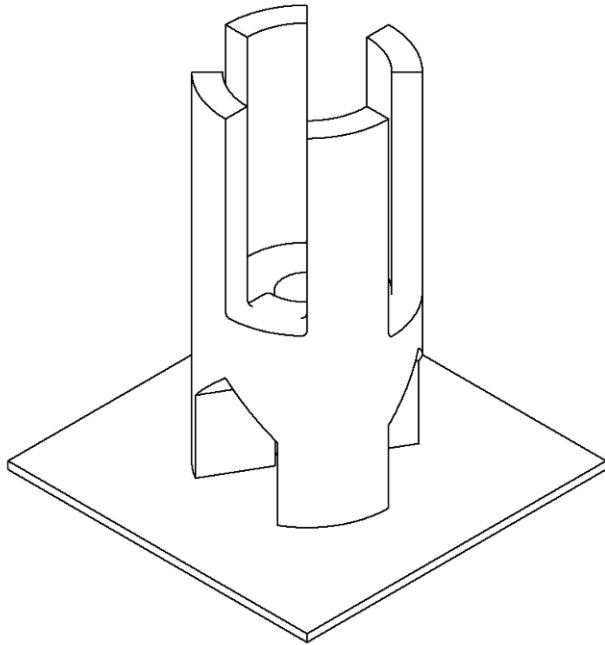


### Insert Fitting

Do not print if you purchased a professionally manufactured one already!

Use support structures on the build plate only.

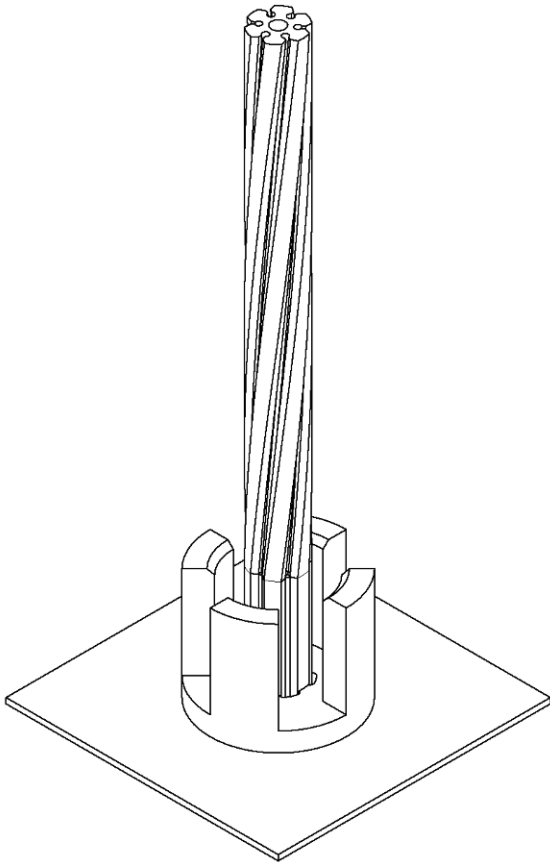
If you substitute your hose with a different diameter, make sure you use the correct size. The default option is 0.75 inches.



### **Boring End Pilot**

Do not use support structures.

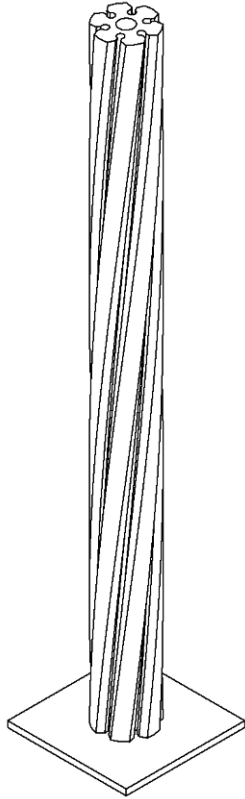
We recommend making more than one in case one gets broken or lost.



### **Rifling Mandrel – Breech End**

Please choose the appropriate piece for your intended barrel length.

10"/250mm barrels will also use the "11 Inch Breech End" piece.



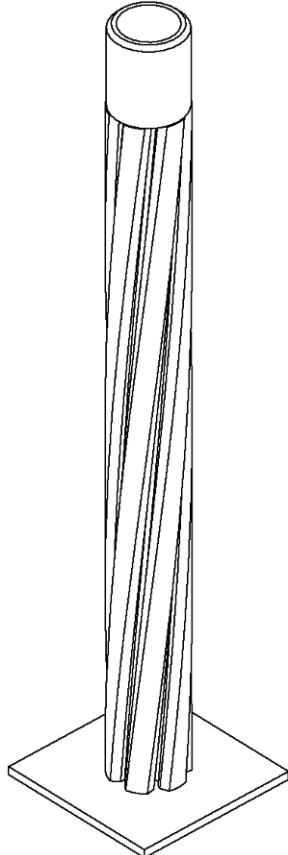
### **Rifling Mandrel – Middle Piece**

Please choose the appropriate piece for your intended barrel length.

16"/407mm barrels will need two of these!

Do not use support structures.

Use of a brim is highly recommended, but please remember to thoroughly clean it out of the channels.



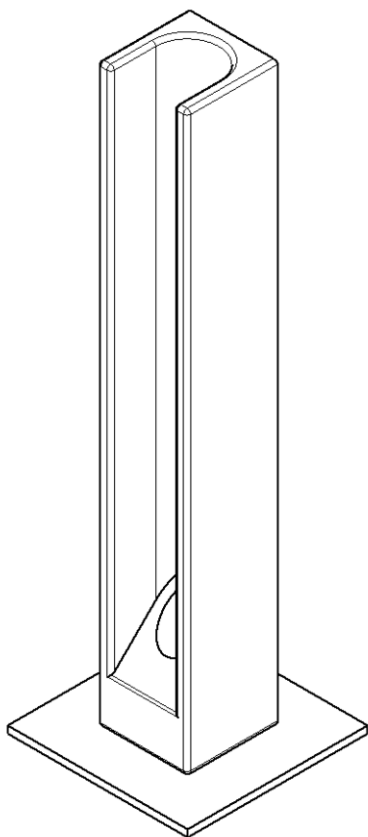
### **Rifling Mandrel – Muzzle End**

Please choose the appropriate piece for your intended barrel length.

Do not use support structures.

Use of a brim is highly recommended, but please remember to thoroughly clean it out of the channels.

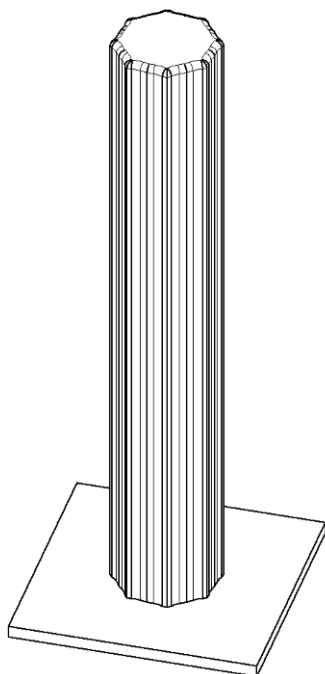
10"/250mm barrels will also use the "11 Inch Breech End" piece.



### **Chambering Tool Spacing Jig**

Do not use support structures.

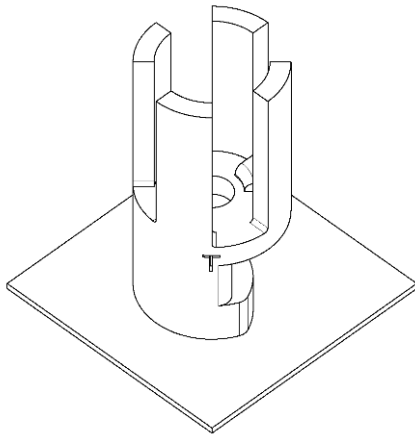
Use of a brim is recommended.



### **Chambering Tool Insulator**

Do not use support structures.

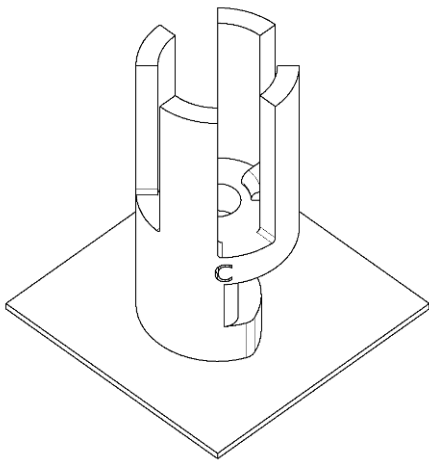
Use of a brim is recommended.



### **Throating End Pilot**

Use support structures.

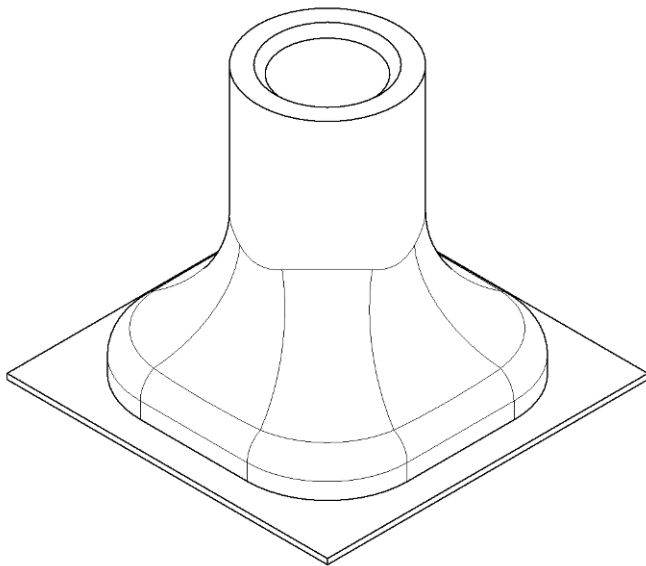
We recommend making more than one in case one gets broken or lost.



### **Chambering End Pilot**

Use support structures.

We recommend making more than one in case one gets broken or lost.

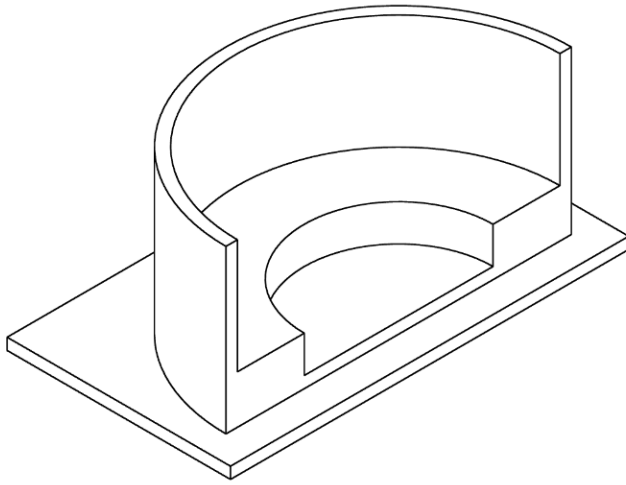


### **Squaring Jig**

No need for support structures.

A reduced infill is acceptable after the first few layers of printed material.

If you have another method to square off a piece of steel, do not print this.



## **Headspacing Gauge**

No need for support structures.

# BARREL STOCK PREPARATION

1. Remove the tube from the packaging. It should be moderately coated in a sticky, oily substance.



2. Spray a cotton patch with brake cleaner. Use a >500mm rod to push this cotton patch through the tube. Repeat this process a few times.

3. Look down the tube while pointing it at a light source. The inside should appear smooth and shiny. **Between this point and completing the ECM process, if you decide to stop and put the tube away, be sure to coat the inside with a film of corrosion-inhibiting oil, like Ballistol for example. Repeat step 2 when you are ready to continue with the process.** If the inside appears smooth and shiny, as depicted, skip step 4 and proceed to step 5.

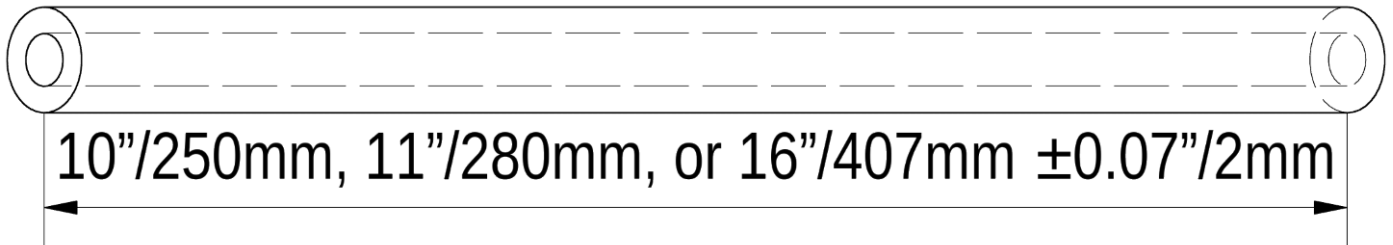


Note: Barrel Stock depicted is shorter for photographic purposes.

4. Rust buildups are resistant to ECM and will not disappear by ignoring them. If the buildups are exclusive to one side of the barrel and close enough to the edge, you may be able to cut it away in step 5. You may also be able to remove the rust building with a drill bit, honing brush, or other improvised honing tool. If the issue is significant, like the image depicts, we recommend returning the tube to the seller.

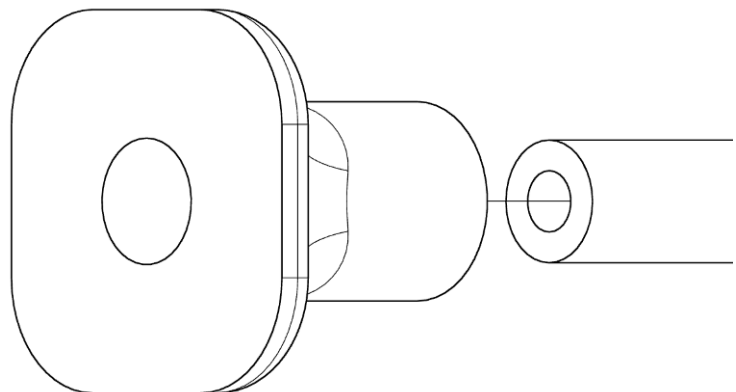


5. Using a chop saw, angle grinder, or other cutting tool, cut the tube to create a 10"/250mm, 11"/280mm, or 16"/407mm section from the hydraulic tubing. Americans building non-NFA firearms may want to overshoot 16" slightly. Your barrel's length can be  $\pm 0.07"/2\text{mm}$ . **If your hydraulic tubing is well squared off on the end that you cut, you may skip the rest of this section.** If not, continue on.

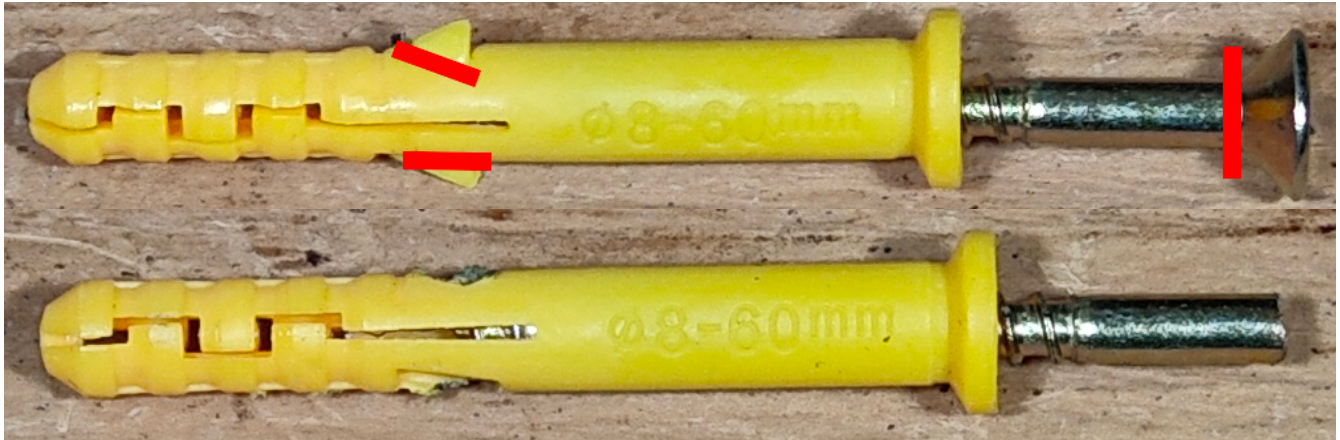


6. At this point, if you have access to a lathe, you will want to use it to square off the piece of tubing you intend to make into a barrel. Once this is done, skip to the next section. If you do not have access to a lathe, that is okay. Simply carry onto the next step.

7. Insert the tube into the Squaring Jig. You may need to twist the tubing and push in order for it to slide in. Let the end that is not well-squared protrude out the flat face.



8. Cut off the flanges from your 8x60mm plastic concrete expander and the head of its screw.



9. Insert the expander into the tube and use your drill to tighten its screw. The tube should catch the expander and start spinning as well.



10. Place a coarse, flat metal file on a hard floor, ideally one that is not sensitive to damage.
11. Use both of your feet to hold the jig flat against the file and spin the tube with the electric drill. Take care not to tilt the tube when completing this step. Continue until the tube is squared off on the end.



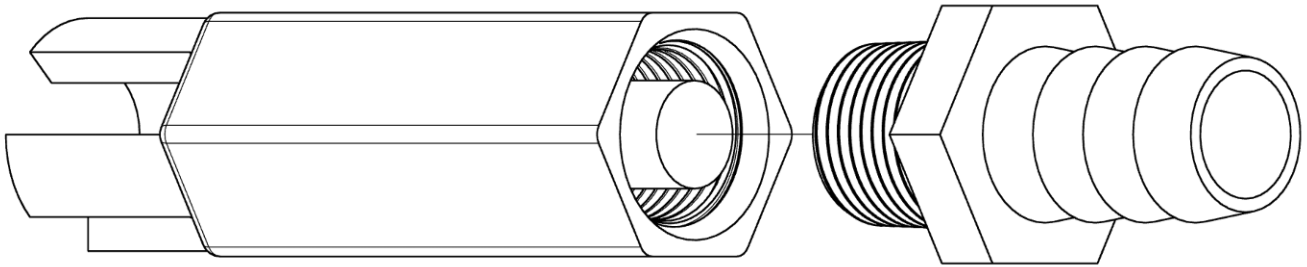
Note: One foot is removed for photographic purposes.

12. Remove the squaring jig and set it aside. With the file, deburr the edges of the tube.

# FIXTURE CREATION

The following instructions apply whether you 3D printed your hose fitting or purchased a professionally manufactured one. Screw the hose fitting into the threaded end of the fixture. The parts should screw together without much resistance. If you feel a lot of resistance, you may be screwing the parts together crooked or the print quality is poor.

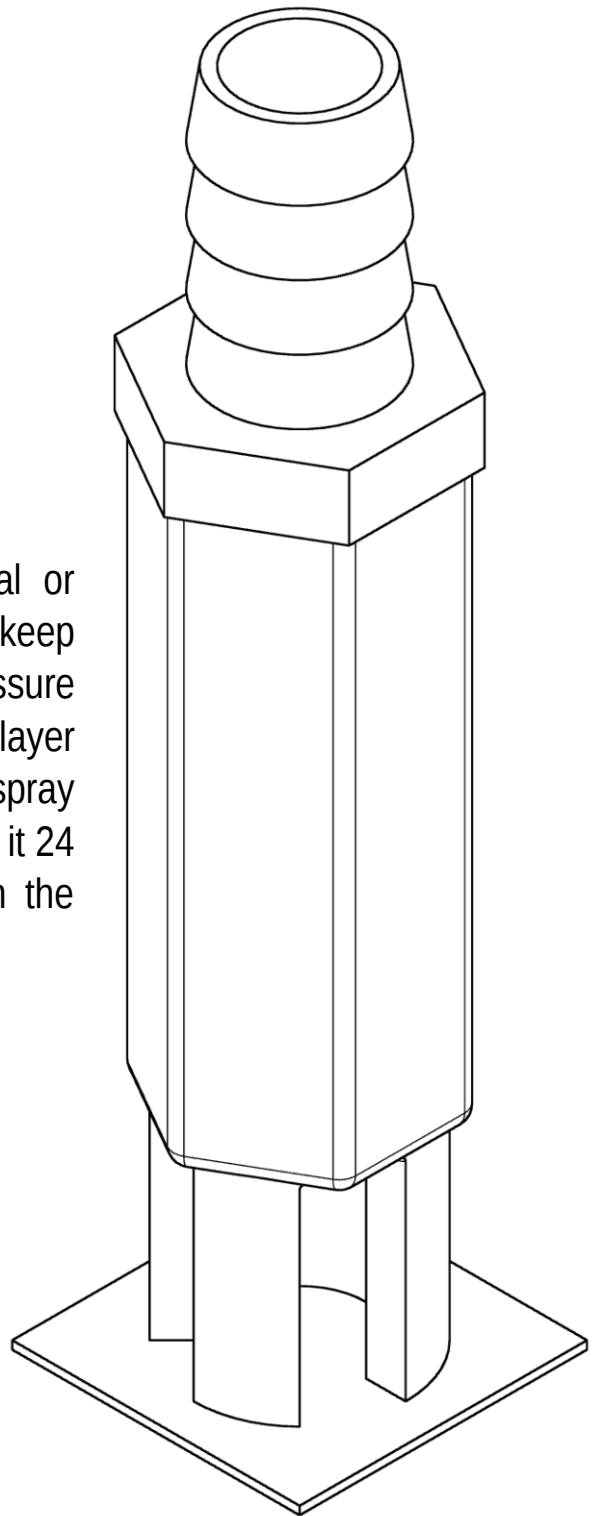
**The two parts may become tight before they fully come together. Do not overtighten.** The fitting has tapered threads, and it seals on the threads instead of the abutting face. Once you feel resistance, that's a sign that the threads are sealing. Move on to the next step once the two parts are tight.



This is what happens when you are a gorilla and did not read the instructions. Do not overtighten.



Optionally, at this point, you may spray-seal or epoxy-seal the fitting and fixture assembly to keep it from leaking. During the higher-pressure operations, some fluid will leak from between layer lines in the fixture, but any epoxy resin or spray sealant should work fine to minimize this. Give it 24 hours to dry after applying, and let it dry in the orientation depicted.



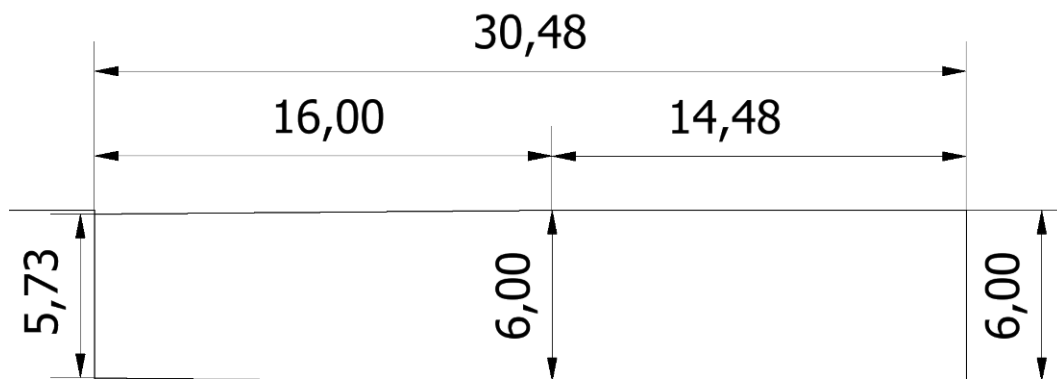
# BORING & CHAMBERING ROD CREATION

The boring rod is simply a long rod cut from your 0.250" or 6mm bar stock. You generally want it 3" or 8cm longer than the barrel you want to make, though its overall length comes with very loose tolerances. If your bar stock came coated, use sandpaper to remove the coating. You want bare metal exposed.

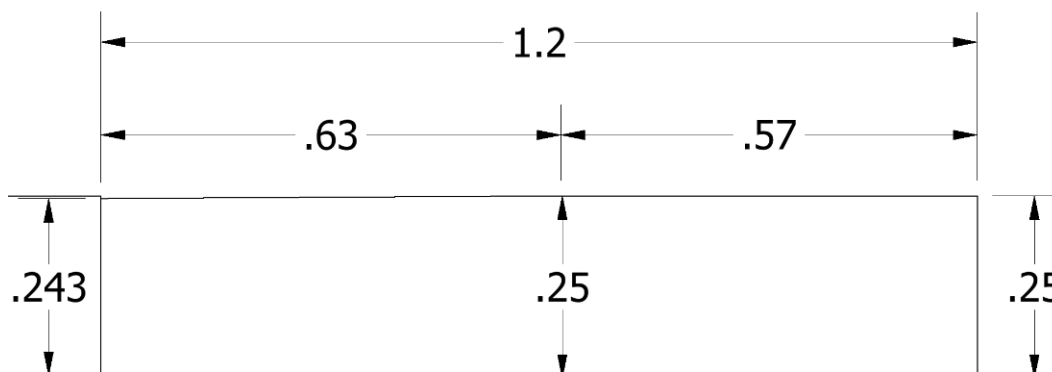
The chambering rod is a 3.00" (7.62cm) long rod cut from your 0.250" or 6mm bar stock. If your bar stock came coated, again, use sandpaper to remove the coating. You want bare metal exposed.

We strongly recommended that you taper the chambering tool in order to add a taper to your chamber. This taper, when used in an ECM setup, approximates the taper found on 9x19mm chambers. It does not have to be highly precise, but adding just a slight taper shape to the chamber will significantly reduce extraction friction.

Taper for 6mm Rod:



Taper for 1/4" Rod:



1. With a caliper, measure the points on the chambering rod which are 0.57"/14.48mm and 1.2"/30.48mm from the end. Use a permanent marker or edges of pieces of tape to mark these points.



2. Chuck up the rod in the drill and set the drill in a bench vise. Use the vise jaws to press the drill's trigger so it spins quickly. (Do not apply excessive force from the bench vise. Doing so will damage your drill.) If you have access to a lathe, you can use that instead.



3. Starting at the small diameter, the 1.2"/30.48mm mark, spin the drill and push the file against the mark. If using a flat file, you can dig in some with a corner.
4. Spin this area down until you have a little shoulder start to develop. This will provide an endstop when you are shaping the rod. Make sure that you form this shoulder exactly at or a little past the small diameter 1.2"/30.48mm mark. If your shoulder forms at 1.3"/33.02mm, that is fine. If it forms at 1.1"/27.94mm, you will need to start over.
5. After grinding a shoulder, take your time and gradually remove more metal to create a taper shape.
6. After shaping the rod with a taper, it is time to mate it with the chamber insulator. Make sure you have access to your chambering tool spacing jig, your chambering tool insulator, your tapered rod, a flat surface, and a little JB-Weld.



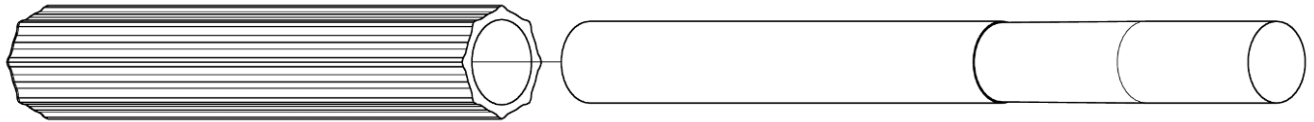
7. Begin by taking a drill bit the same size as your chambering tool rod ( $\frac{1}{4}$ " or 6mm) and ream out the small hole in the chambering tool jig. Ensure that the rod can pass freely through this hole.



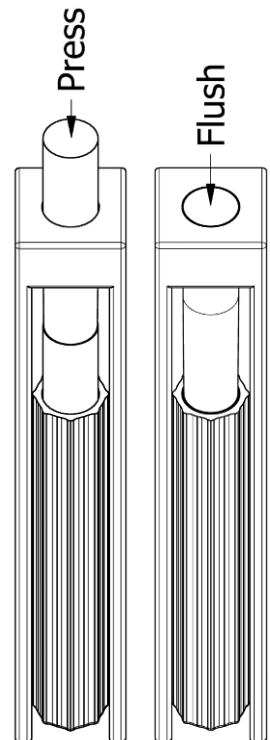
8. Prepare the chambering tool insulator by ensuring that the bottom of the insulator isn't smushed out where it was touching the print bed, especially if you printed with a brim. Remove anything that is shaped like a brim.
9. Mix a drop of JB-Weld and apply it to the mouth of the chambering tool insulator.



10. Take your tapered rod, **paying close attention to which end has the taper**, and stick the end that **does not** have any taper down into the hole first.



11. Push the rod down from the top and into the insulator, sitting inside the jig.
12. Once the rod is pushing inside the insulator, stand the jig and tool upright. With the bottom of the jig and bottom of the insulator on a flat surface, push down on the top of the rod using a flat surface or tool.
13. After pushing the rod flush with the jig, let the rod/insulator sit inside the jig for 12-24 hours while the JB-Weld cures. After this time, you should be able to remove the chambering rod from the jig.
14. Use a file or screwdriver to clean off any JB-Weld that got on the outside of the insulator or metal rod.



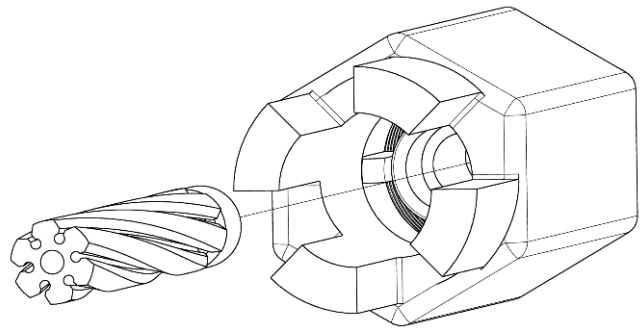
# RIFLING MANDREL CREATION

For the rifling mandrel, you will need to attach a few long, slender objects together and dress them with bare, copper wires. Pay close attention to the following steps, as this is the most difficult tool to make.

1. Use a caliper to measure the diameters of your mandrel pieces. They should all be slightly under 8.82mm. If their diameters are any wider, you will have difficulty inserting them into your barrel. In this case, check your printer's calibration and try printing them again. If not, continue on.



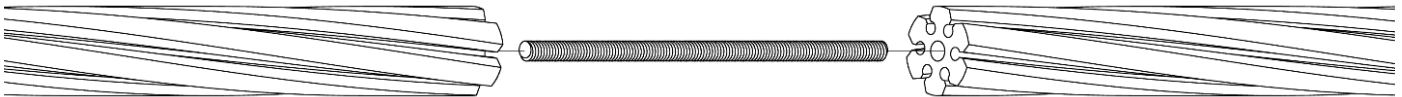
2. Insert the muzzle end of the rifling mandrel into the fixture. It should fit tightly, but come in and out smoothly. If it is too difficult to insert and remove, you may need to sand down the surface of the rifling mandrel that fits into the fixture.



3. Use a dental pick, needle, or other pointy tool to ensure that the channels are clear of any print debris. Also ensure that the surface of the mandrel is clear of any deformities.



4. If you are creating a 10"/250mm barrel or 11"/280mm barrel, you will need two 50mm long M2 threaded rods. If you are creating a 16"/407mm barrel, you will need three 50mm long M2 threaded rods. Cut these accordingly.
5. The threaded rods will fit loosely into the holes on the tops and bottoms of the mandrel pieces. Insert them accordingly. Note that these are only intended to add rigidity to the final tool and not to secure the pieces together. The wires will take care of that.



6. If you are creating a 10"/250mm barrel, you will work with 13"/330mm of wire per channel. If you are creating an 11"/280mm barrel, you will work with 14"/356mm of wire for each channel. If you are creating a 16"/407mm barrel, you will work with 19"/483mm of wire for each channel. Unwind the appropriate length of wire from the coil.
7. To straighten the wire, we recommend simply pulling the wire outward and running it between your fingers. Do not bend the wire as you pull it, as that will cause it to coil. If you struggle with this, look up "copper wire straightening" online.

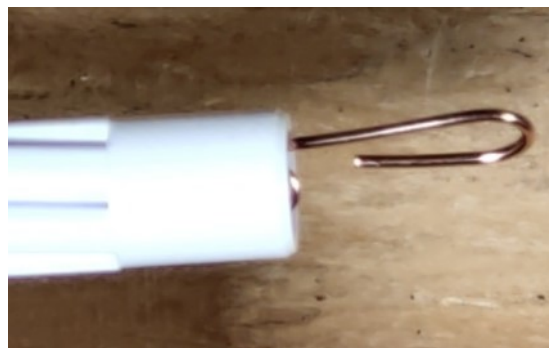


8. Carefully insert the wire into either end of the mandrel. It should slide in easily, but if you encounter resistance, we recommend using a pair of pliers to push a few millimeters of wire in at a time. Go slow. It is not a race.

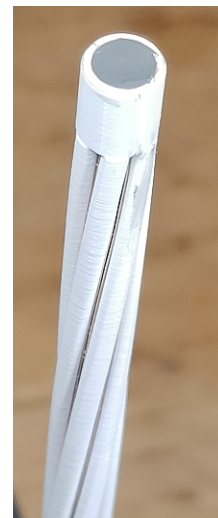


- a. If you push too hard, the wire may kink. If the wire kinks, you can try to straighten it out. However, be aware that excessive kinking will complicate the insertion of the wire to a point where you may want to start that channel over.
- b. When inserting your first wire, rotate the pieces so they are aligned and flush. Remember that the wires will primarily hold the mandrel together.

9. When the wire is fully inserted, cut it off the spool, leaving a few centimeters protruding out the bottom, and make a hook shape on the top end. This is important to complete the next step. Repeat from step 6 until all channels are dressed with wire.



10. Fill the void on the top piece with JB-Weld. Make sure all the wire hooks are submerged and the wire channels stay clean. Wait 24 hours for the JB-Weld to cure.



11. Grab the mandrel by the bottom piece and pull the protruding wires taut. Ensure that the mandrel pieces are flush with one-another.



12. Twist the wires under the bottom piece of the mandrel as depicted.



Your rifling mandrel is ready for action!



# THE ECM PROCESS



**This is the point of difficult return.** That is not to say this is the point of no return, but stopping the process and then starting again later may jeopardize the quality of your barrel. While you should have read this entire document before starting anything, please make sure you read and understand all the steps in this process and are sure you can complete them, ideally uninterrupted. From experience, this process generally takes around four to six hours.

The next few sections will instruct you through turning your barrel stock into a functioning barrel. If you make a mistake, you may need to start over. Please pay serious attention to every detail. Everything we wrote is here for a reason.

This is not recommended, but if you need to stop and continue the process at a later time, please flush your barrel with freshwater, inside and out, and apply a thin layer of oil to keep it from rusting. Clean out the inside with brake cleaner and cotton patches when you are ready to start again.

# RESERVOIR & PUMP SETUP

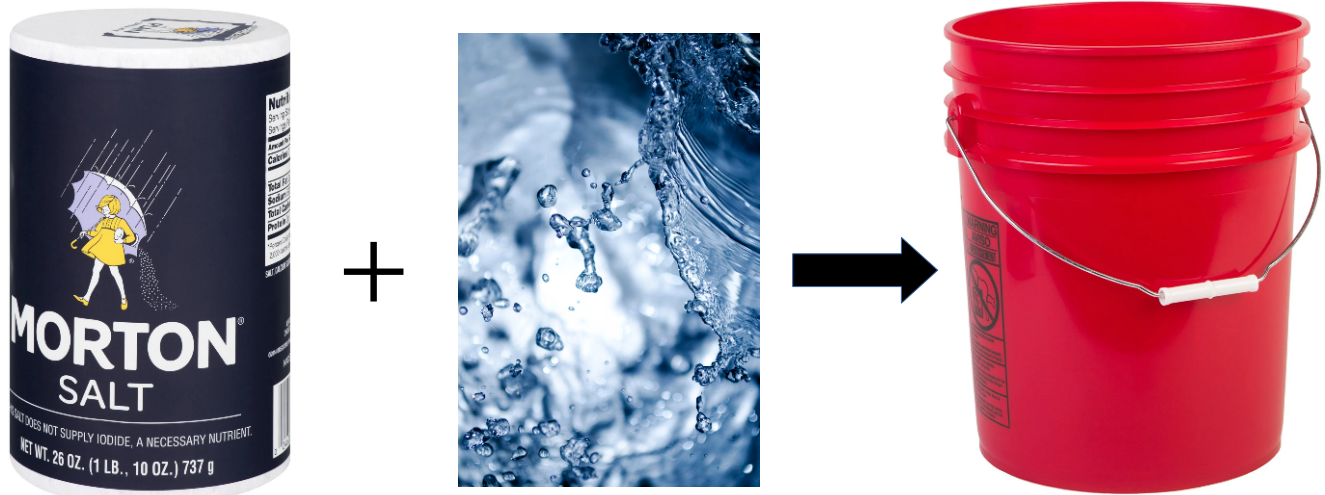
At the core of the electrochemical machining process is the electrolyte pump system. This system draws electrolyte from the reservoir and pumps it through the barrel, enabling an electrical connection and flushing out sludge. As the reservoir retains sludge, some sludge will cycle through the tube repeatedly. While this is not ideal, it is not a serious issue as far as creating a functional barrel is concerned.

For this process, we recommend the “Vivosun 800GPH Submersible Pump”. We appreciated that it would connect directly to a wall outlet and had a sufficient flow rate. Upon testing, the flow rate was less than 800 gallons per hour, but it was still fast enough to meet expectations.



This pump, of course, is not your only option. If you have the pump in the ECMv2 guide, that should work as well, although from prior experience, we found it easier to utilize a regular 12V 5A power supply instead of a lithium-ion battery. If you use the pump in the ECMv2 guide, you will need to use a smaller hose diameter and the 0.5” insert fitting included in the ECMv2 files.

The electrolyte will be a saltwater mixture. We recommend 25 grams of salt per gallon or 6.6 grams of salt per liter. This is 25% of what the ECMv2 guide recommends. You are welcome to experiment with differing quantities of electrolyte in the reservoir, though we recommend 3 gallons in a 5 gallon bucket or 11.3 liters in a 19 liter bucket. Three gallons of electrolyte will require 75 grams of salt.



Measure the appropriate amount of water and pour it into the bucket or container you intend to use for the reservoir. Weigh the appropriate amount of salt and pour it in too. Stir the mixture until you no longer feel any salt granules at the bottom of the reservoir.

If you used the pump described in this section, start by ensuring that the insert fitting on the pump is securely screwed into place and that the appropriately-sized hose is attached to the barbed end with a hose clamp or two. Submerge the pump with the attached hose into the reservoir. Hold the other end of the hose over the reservoir and turn the pump on. Electrolyte should flow through the hose and drop back into the reservoir. Turn the pump off when you are satisfied.

If you used a pump described in a previously published version of the ECM documentation, please follow that section of the documentation accordingly. If you acquired a different pump, we trust you to figure out how to test it.



Place a camera tripod over your reservoir. You will need it to position the end of the ECM tooling assembly over the reservoir. You may find a welding clamp or some tape helpful to keep it in place.



Attach the insert fitting and fixture to the other end of the hose with a hose clamp. Drape the hose over the top of the camera tripod so the end points toward the reservoir.



# BORING PROCESS

The purpose of the boring process is to increase the inner diameter of your barrel to what will become the hill-to-hill distance. For 9mm Luger, this is **8.82mm**. If this is overshot slightly, that is still acceptable.

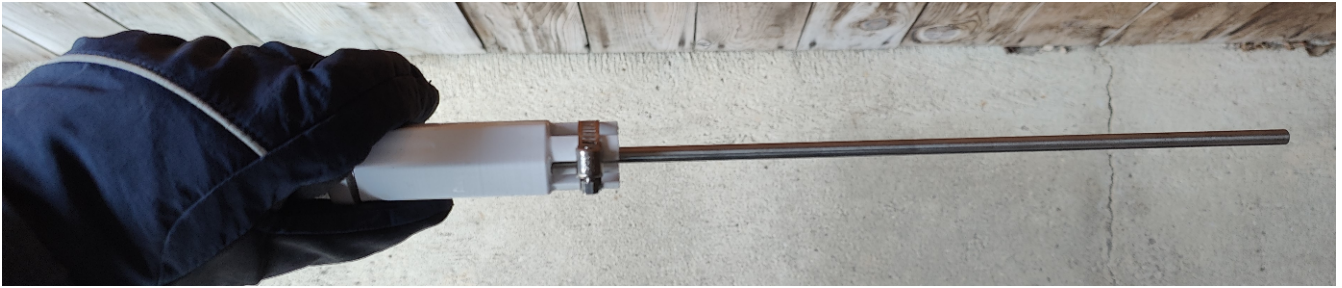
Compared to the ECMv2 guide, the electrolyte's salinity is significantly reduced. This is to prevent accidental conical cutting on this step. However, the time to bore out the barrel with the same power supply in the ECMv2 guide would take a much longer amount of time. For this reason, we recommend using an arc welder for this stage of the process.

Use of an arc welder will involve much more, potentially lethal current. It will also create a lot of hydrogen gas while cutting, requiring that you complete at least this stage of the process outdoors. If this is too risky for you, you do not own an arc welder, or you cannot do this outside without drawing unwanted attention, you may use the regular power supply instead. The following instructions will explain how to set up either option.

1. Spray a cotton patch with brake cleaner and use your boring rod to push it through your barrel. Repeat this process a few times until the patch comes through generally clean and the inside of the barrel looks shiny.



2. Insert the boring rod into the fixture. It should feel somewhat tight and come to a hard stop.



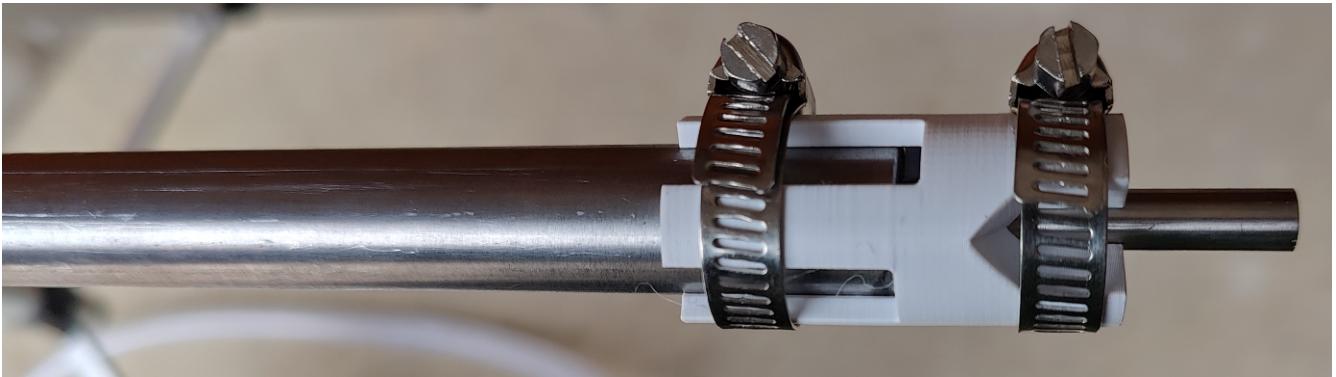
3. Insert your barrel around the boring rod and into the fixture. Make sure that the boring rod has not come loose inside the fixture. Apply and tighten a hose clamp to the fingers around the fixture.



4. If you are not using an arc welder, take a piece of wire with the end stripped and hose clamp the bare copper to the surface of the barrel.



5. Slide the center hole in the boring end pilot through the piece of the boring rod that is sticking out. Apply and tighten two hose clamps around the fingers on both ends of the boring end pilot.



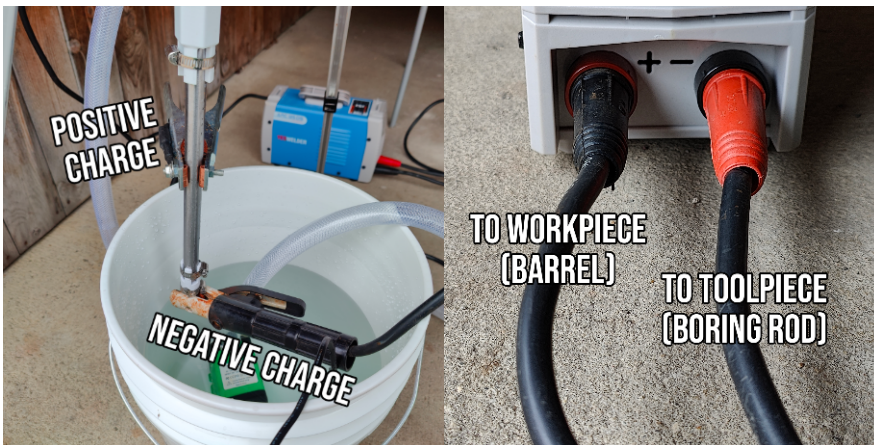
6. Ensure that the assembly is positioned over the reservoir. The electrolyte will spray in two horizontal directions from the boring end pilot, so we recommend ensuring that it is positioned below the rim of the reservoir.
7. Turn on the pump. Electrolyte should flow through the pump, hose, fitting, fixture, barrel, and boring end pilot. Ensure that the electrolyte ends up back in the reservoir. There may be a little leakage between the fixture and barrel, but it should not be significant. Turn off the pump when you feel satisfied.



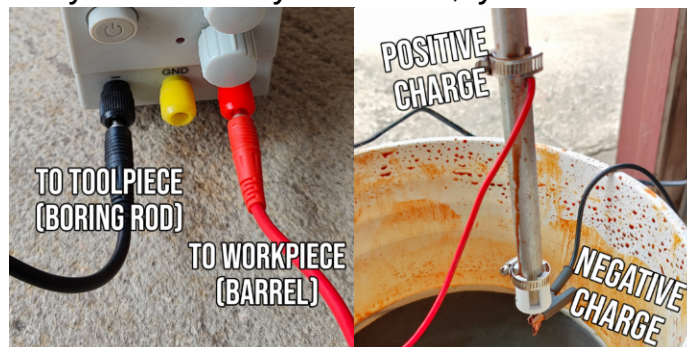
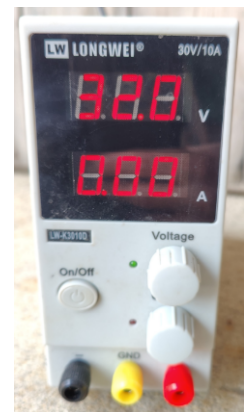
- a) If you are using an arc welder, make sure nothing is connected to it and set it to 100 amps. Shut the welder off after you have the current set. Attach the grounding clamp to the barrel and the electrode holder to the end of the boring rod that is sticking out of the end pilot. On the welder, attach the grounding clamp cable to the positive port and the electrode holder cable to the negative port. (This is akin to straight polarity in welding terms.) It is critical that you get the polarity correct. If you do not, you will ruin your boring rod.



Note: Turn off after setting until instructed otherwise. Do not electrocute yourself.



- b) If you are not using an arc welder, turn the power supply to its maximum output. Turn the power supply off, then attach an alligator clamp to the other end of the wire hose clamped to the barrel and attach another alligator clamp to the end of the boring rod that is sticking out of the boring end pilot. Connect the wire attached to the boring rod to the negative port and the wire connected to the barrel to the positive port. It is critical that you get the polarity correct. If you do not, you will ruin your boring rod.



Note: Photo depicts the rifling mandrel, but the same concept applies to the boring rod.

8. Please read through this entire step and steps 9 & 10 before taking any action. Turn the pump on. After the electrolyte starts flowing through the barrel, turn the power supply or arc welder on. The electrolyte coming out of the end pilot should appear cloudier, and you will hear a hissing sound. You will also see a faint, white gas emanating from around the end pilot and ejected electrolyte. This will begin the first cutting increment.

9. Between cutting increments, take the assembly apart, clean the inside of the barrel with brake cleaner and cotton patches, use a caliper to measure the inner diameter, then reassemble by repeating steps 2 through 9. You will find your boring rod useful for pushing cotton patches down the barrel. This may seem tedious, but it is much easier to stop and measure than to have to start over.



a) With an arc welder, to increase the inner diameter of the barrel from 8mm to 8.82mm, we needed to cut for a total of around 15 minutes. However, we recommend cutting in increments of 3 minutes. As the inner diameter comes within 8.6-8.7mm, we recommend cutting in 1 minute increments. Past 8.7mm, we recommend cutting in 30, 10, or 5 second increments.

b) With a regular power supply, to increase the inner diameter of the barrel from 8mm to 8.82mm, we needed to cut for a total of around several hours. However, we recommend cutting in increments of 30 minutes. As the inner diameter comes within 8.6-8.7mm, we recommend cutting in 10 minute increments. Past 8.7mm, we recommend cutting in 5, 2, or 1 minute increments.

10. Once your barrel has an inner diameter of 8.82mm, you are ready to move onto the rifling stage of the ECM process. A good way to test this is to try pressing your rifling mandrel down the bore after cleaning with brake cleaner. If it is difficult to push it in, stop, push it out with your boring rod, and cut a little more.

# RIFLING PROCESS

The purpose of the rifling process is to cut a helical pattern in the majority of your barrel to a valley-to-valley distance of **9.01mm**. This is the distance recommended by ImmortalRevolt in the ECMv3 guide, and it will maximize the velocity of the bullet.

In the ECMv2 guide, the recommend valley-to-valley distance was 9.3mm -0.2 +0.1. We believe this decision was made in an abundance of caution, but it was later deemed unnecessary. This is, however, an option to bleed off gasses and reduce the velocity of the bullet if you would like to shoot suppressed. This option is not ideal when compared to integral suppression, but it is more expedient. Though this would be experimental, we believe the valley-to-valley distance could go up to 9.6mm, as it is in the Heckler & Koch VP70.

If you used an arc welder, set it aside. You should not use it for the rifling process or any further processes. If you do, you may melt the rifling mandrel and possibly destroy your barrel. Use a regular power supply instead.

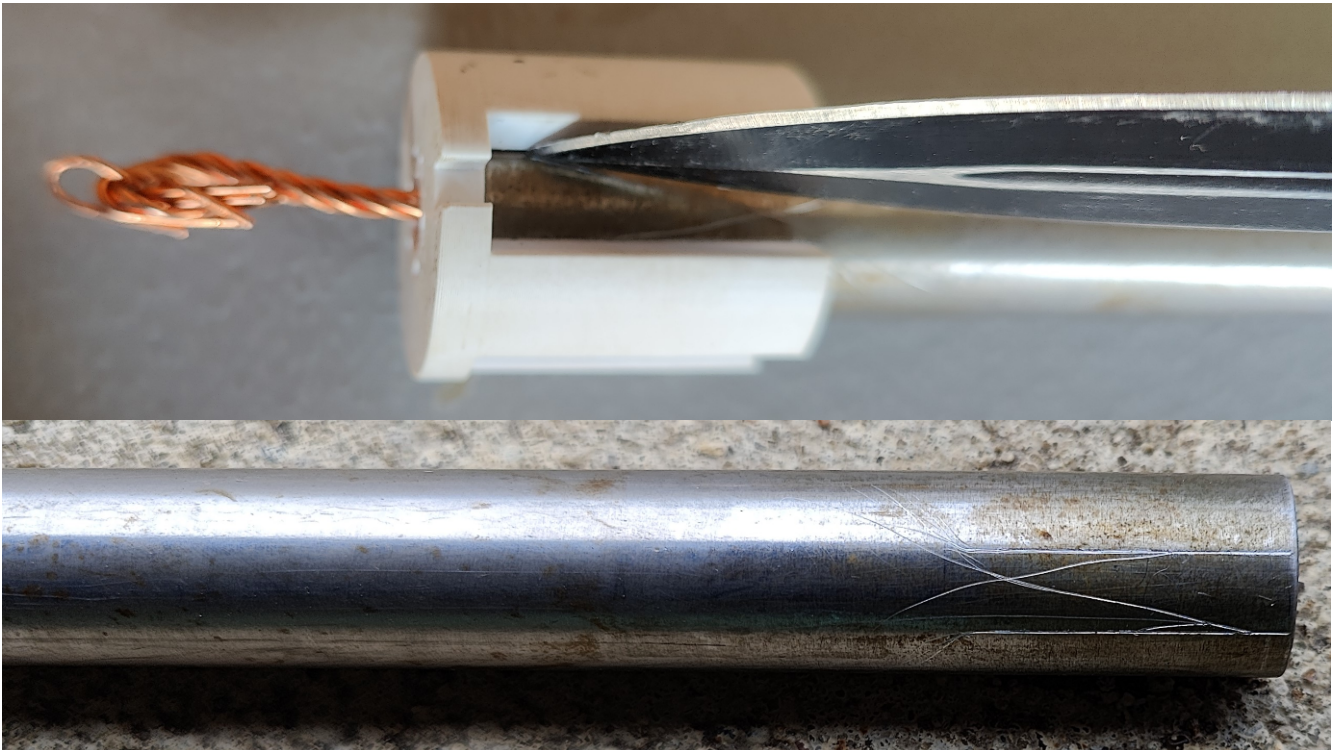
1. If you did not already do so during the boring process, take a piece of wire with the end stripped and hose clamp the bare copper to the surface of the barrel.



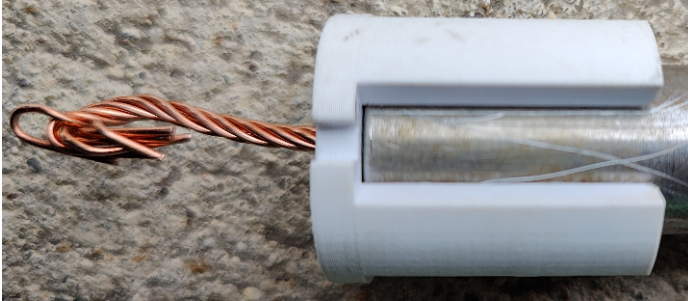
2. Push the mandrel all the way into your barrel as far as it will go.



3. The first time you insert the mandrel into your barrel, you will need to make indexing marks. To do this, start by finding the gap that has a square cutout between two fingers on the mandrel. Then, use a boxcutter, screwdriver, knife, or other sharp metal tool and make visible scratches in the finish of the barrel using the fingers of the mandrel as a guide. Note the markings in the bottom picture.



4. From now on, **EVERY** time you mate the rifling mandrel and barrel together, you must make sure that the scratches you made line up with the fingers that are adjacent to the square cutout on the mandrel. As long as you ensure that the mandrel and barrel line up in this manner, you won't have any alignment/index issues. Do not spin the rifling mandrel in the barrel once it is aligned.

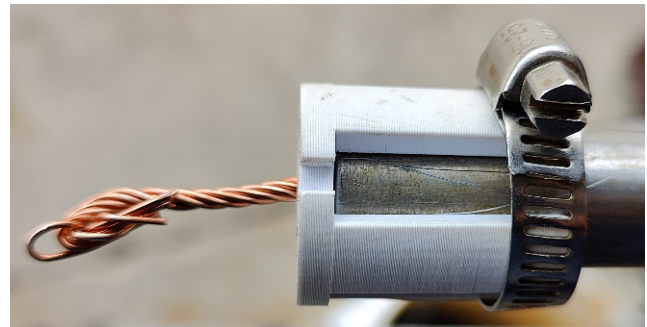


**GOOD**



**BAD**

5. Double checking that the mandrel has been inserted into the barrel as deeply as possible, use a hose clamp to secure its fingers to the surface of the barrel.



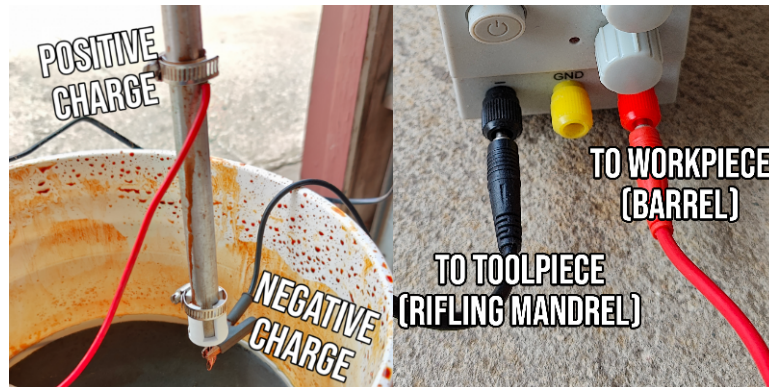
6. Push the barrel with the mandrel inserted into the fixture as far as it will go. Ensure that the barrel stays fully seated against the mandrel and that the mandrel did not back out while inserting it into the fixture. Do not spin the mandrel inside the barrel while inserting them into the fitting, as that would mess up the alignment.
7. Install a hose clamp onto the fixture. Double check that the rifling mandrel is fully inserted into the fixture before tightening the hose clamp. Check the rifling mandrel's alignment one more time.



8. Turn on the pump. Electrolyte should flow through the pump, hose, fitting, fixture, barrel, and rifling mandrel. Ensure that the electrolyte ends up back in the reservoir. There may be a little leakage between the fixture and barrel, but it should not be significant. Turn the pump off when you are satisfied.



9. Turn the power supply to its maximum output if you have not already. Make sure the power supply is off, then attach an alligator clamp to the other end of the wire clamped to the barrel and attach another alligator clamp to the end of the copper wires that are sticking out of the rifling mandrel. Connect the wire attached to the rifling mandrel to the negative port and the wire connected to the barrel to the positive port. It is critical that you get the polarity correct. If you do not, you will ruin your rifling mandrel.



10. Turn the pump on, then turn the power supply on. We recommend starting by cutting for three minute increments and using your best judgment from there. By completing the boring process, you should have a feel for how to adjust the cut time increments.
11. Between cutting increments, take the assembly apart, clean the inside of the barrel with brake cleaner and cotton patches, use a caliper to measure the valley-to-valley distance, then reassemble by repeating steps 4 through 9. You will find your boring rod useful for pushing cotton patches down the barrel. This may seem tedious, but it is much easier to stop and measure than to have to start over.

- a) In order to disassemble these tools, remove the hose clamp or zip tie on the fixture and pull the barrel from the fixture. Then, remove the hose clamp or zip tie from the rifling mandrel and **push** it out from the end that was inserted into the fixture. Never pull the rifling mandrel out of the barrel as doing so may damage it. You may find your boring rod useful to push the rifling mandrel out of the barrel.
12. Once your barrel has a valley-to-valley distance of 9.01 or greater if you choose, you are ready to move onto the throating & chambering stage of the ECM process.



# THROATING & CHAMBERING PROCESS

The purpose of the throating and chambering process is to cut a small section of the barrel which retains cartridges until after detonation. The chamber does the retention, and the throat is a section which transitions between the chamber and rifling, ensuring that the bullet does not crash into the rifling when the cartridge is loaded into the chamber.

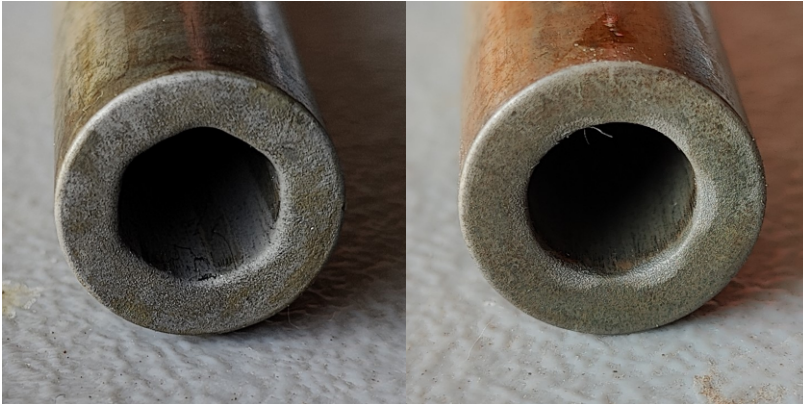
You will use the same toolpiece, the chambering rod, to cut the throat and chamber. The only difference between the two cutting processes is that the throating end pilot seats the chambering rod 2mm deeper than the chambering end pilot.

You should have tapered your chambering rod upon creation. This is to improve reliable case ejection. The easily measurable diameters of the throat and chamber account for this. When measuring from the breech during the throating process, you will want to achieve an inner diameter of **9.05mm -0 +0.03**. When measuring from the breech during the chambering process, you will want to achieve an inner diameter of around **9.94mm**, but the completion of this step is properly gauged by the insertion of a 9x19mm Luger cartridge.

1. Your positive current wire should remain attached. If it isn't, take a piece of wire with the end stripped and hose clamp the bare copper to the surface of the barrel.



2. Install the **muzzle end** of the barrel fully into the fixture. The muzzle end is the end with the rifling profile visible, a hexagon shape with rounded corners. The other end is the chamber end, and it should be round. You will not insert any tools into the fixture. Apply a hose clamp to retain the barrel in the fixture.

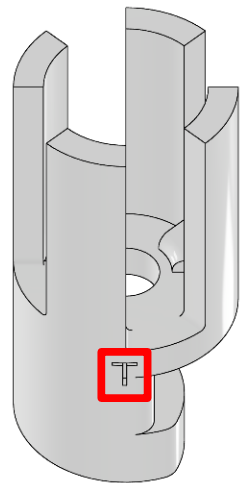


Muzzle End  
Goes Inside Fixture

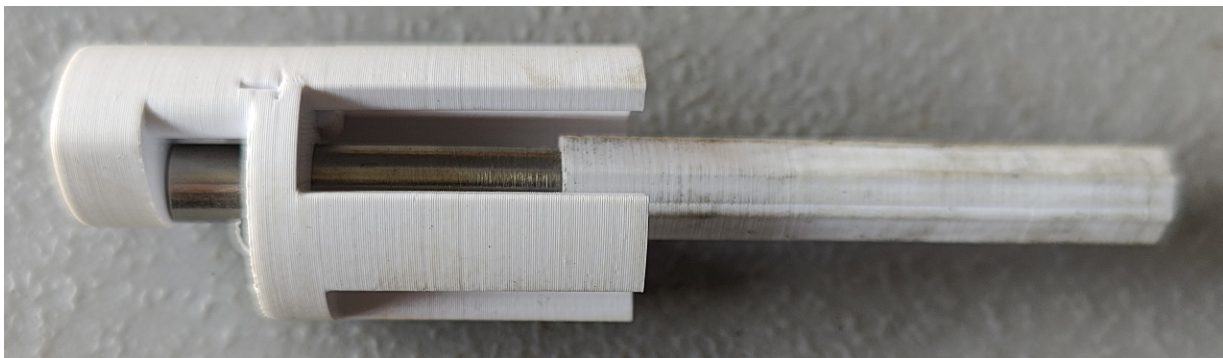
Chamber End  
Accepts Chambering Rod



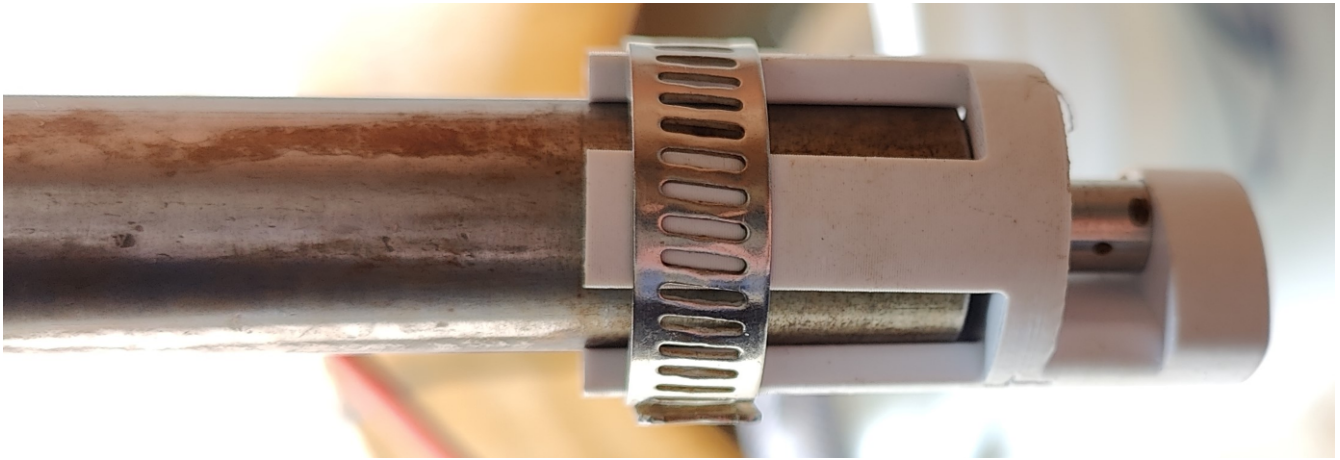
3. Identify your throating end pilot. This is the end pilot with a “T” embossed on it. If you see a “C” embossed on it, that is the wrong one. Make certain that it has a “T” embossed on it. If you get this wrong, it is because you are dumb, and you will be very sad.



4. Insert the exposed end of the chambering rod into the throating end pilot. Make sure that the end of the chambering rod is pressed against the end pilot's shelf.



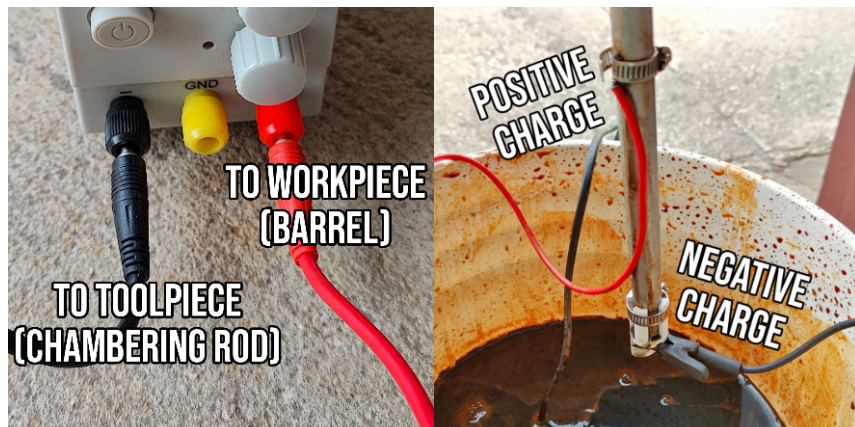
5. Insert the throating end pilot and chambering rod into the barrel. Make sure you insert the throating end pilot completely, and secure it in place with a hose clamp.



6. Turn on the pump. Electrolyte should flow through the pump, hose, fitting, fixture, barrel, and throating end pilot. Ensure that the electrolyte ends up back in the reservoir. There may be a little leakage between the fixture and barrel, but it should not be significant. Turn off the pump when you are satisfied.



7. The power supply should remain set to its maximum output. Make sure the power supply is off, then attach an alligator clamp to the other end of the wire clamped to the barrel and attach another alligator clamp to the end of the chambering rod. Connect the wire attached to the chambering rod to the negative port and the wire connected to the barrel to the positive port. It is critical that you get the polarity correct. If you do not, you will ruin your chambering rod.

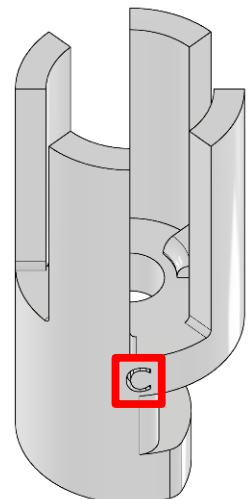


8. Double check that the end of the chambering rod is pressed against the shelf in the throating end pilot. The downward force of the electrolyte should assist in keeping it in place.
9. Turn on the pump. Then, turn on the power supply to start cutting. We recommend starting cutting in 1 minute increments and using your best judgment from there.
10. Between cutting increments, take the assembly apart, clean the inside of the barrel with brake cleaner and cotton patches, use a caliper to measure the diameter at the breech, then reassemble by repeating steps 5 through 9. You will find your boring rod useful for pushing cotton patches down the barrel. This may seem tedious, but it is much easier to stop and measure than to have to start over.

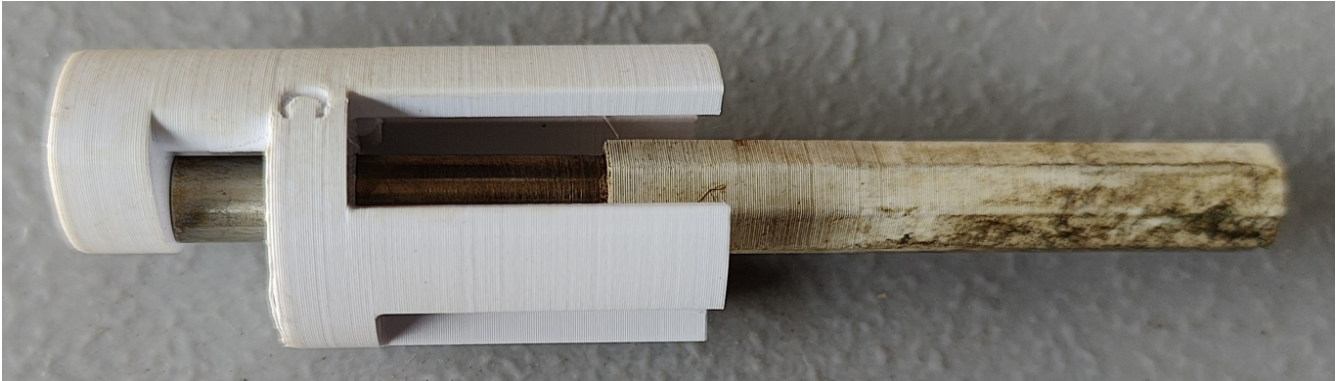
11. Once you measure an inner diameter of 9.05mm  $-0$   $+0.03$  at the breech, you are ready to move onto the chambering stage of the ECM process. Reassemble everything short of inserting the end pilot.



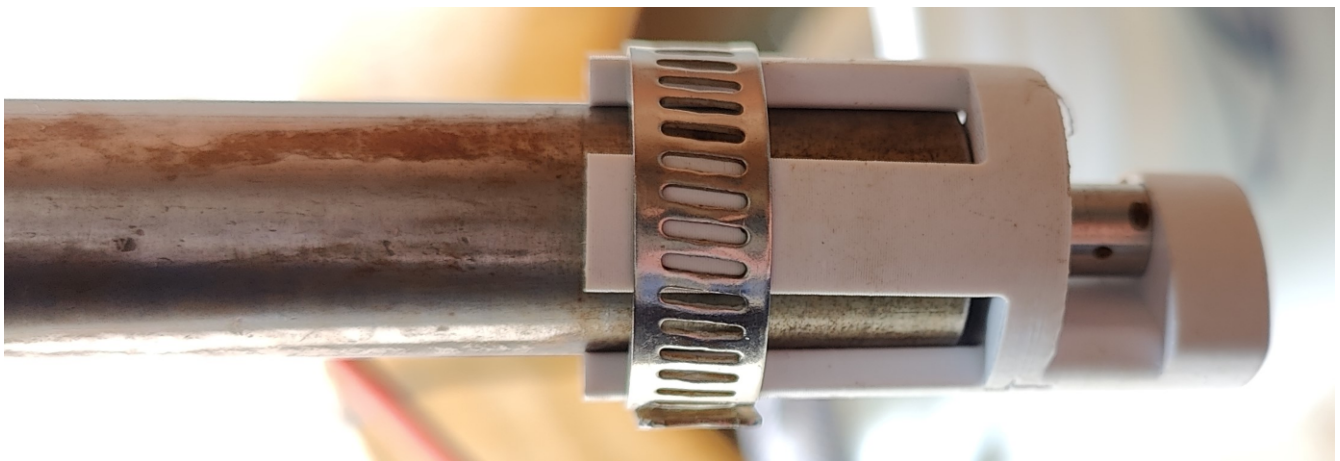
12. Identify your chambering end pilot. This is the end pilot with a "C" embossed on it. You can't possibly get it wrong at this point, right?



13. Insert the exposed end of the chambering rod into the chambering end pilot. Make sure that the end of the chambering rod is pressed against the end pilot's shelf.



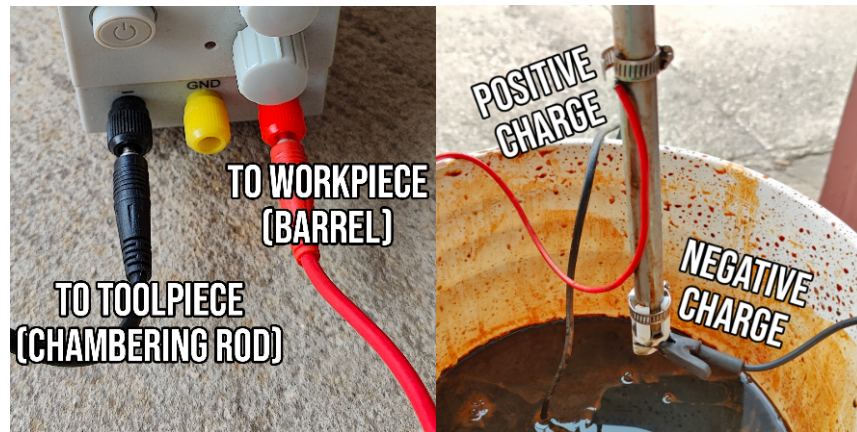
14. Insert the chambering end pilot and chambering rod into the barrel. Make sure you insert the chambering end pilot completely, and secure it in place with a hose clamp.



15. Turn on the pump. Electrolyte should flow through the pump, hose, fitting, fixture, barrel, and chambering end pilot. Ensure that the electrolyte ends up back in the reservoir. There may be a little leakage between the fixture and barrel, but it should not be significant. Turn off the pump when you are satisfied.



16. Your positive connector should remain attached. If it isn't, repeat step 1. Attach an alligator clamp to the end of the chambering rod, and connect it to the negative port on your power supply.



17. Double check that the end of the chambering rod is pressed against the shelf in the chambering end pilot. The downward force of the electrolyte should assist in keeping it in place.
18. Turn on the pump. Then, turn on the power supply to start cutting. We recommend starting cutting in 1 minute increments and using your best judgment from there.
19. Between cutting increments, take the assembly apart, clean the inside of the barrel with brake cleaner and cotton patches, use a caliper to measure the diameter at the breech, then reassemble by repeating steps 14 through 18. You will find your boring rod useful for pushing cotton patches down the barrel. This may seem tedious, but it is much easier to stop and measure than to have to start over.
20. The diameter of the breech should be around 9.94mm upon completion, but the only way to test is to insert a 9x19mm Luger cartridge into the chamber. It should seat completely, as depicted, and come out with relative ease. It should protrude approximately 3.2mm from the chamber.



21. Once you confirm that a cartridge can be inserted and removed from the chamber with relative ease, your chamber is complete.
22. Clean the inside of your barrel with brake cleaner and cotton patches one more time. Flush the inside and outside of your barrel with freshwater and apply a thin layer of corrosion-inhibiting oil. You will find your boring rod and cotton patches helpful for this step.

The electrochemical machining processes are now complete. You can clean everything up now. We recommend flushing anything that contacted the electrolyte in freshwater, especially your pump.

The final remaining steps will not require any of the tools you used during this process.

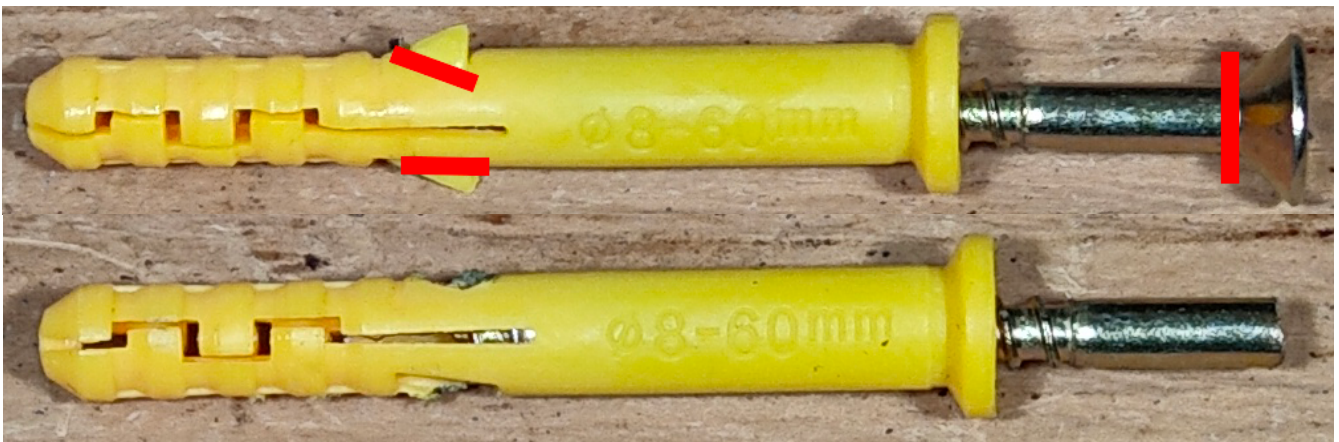
# POST PROCESSING

The electrochemical machining process is complete. The following instructions will guide you through a few more steps you will need to complete in order to utilize your ECM barrel to its greatest potential.

## SHAFT COLLAR FITTING

To retain your barrel in your gun, you will need to apply three DIN 705 shaft collars. Remove the retention screw from one of the shaft collars and try to place it around the chamber. If it slides on easily, proceed to the headspacing section. If not, your barrel may be slightly oversized, and we recommend using a caliper to confirm. If it is oversized, please start from step 1.

1. If you do not still have the concrete expander you may have used during the barrel stock preparation section, cut off the flange from another 8x60mm plastic concrete expander and the head of its screw.



2. Insert the expander into the barrel on the chamber end and use your drill to tighten its screw. The tube should catch the expander and start spinning as well.



3. Hold your drill in one hand. In your other hand, hold a piece of sandpaper wrapped around the first 4cm of breech-end of your barrel. Spin the drill and turn down the surface of the barrel. The goal is to get the area where the shaft collars rest slightly under 16mm in diameter. Periodically, wipe off the debris and try fitting a shaft collar in place. If it fits, remove it, apply a thin film of corrosion-inhibiting oil to the area you filed down, and proceed to the headspacing section.

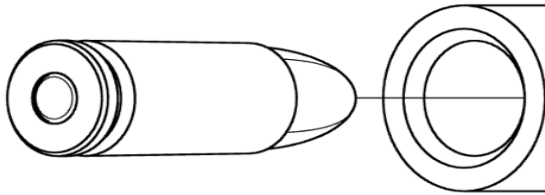


# HEADSPACING

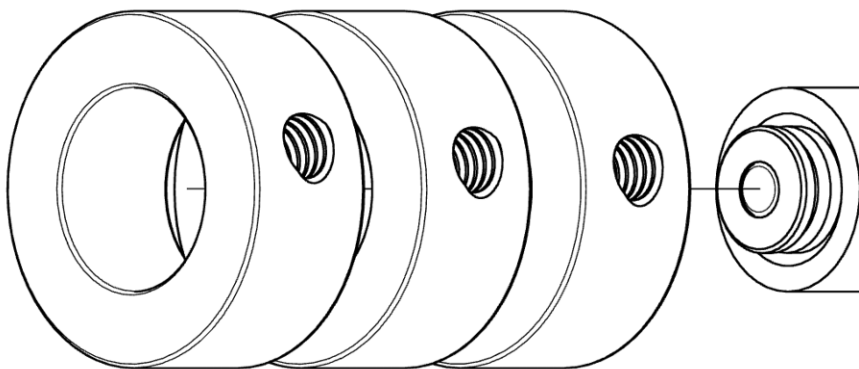
Headspacing refers to the measurement of the distance between the face of the firearm's bolt and the part of the chamber that stops the forward motion of the cartridge, known as the datum line. Proper headspacing is crucial for the safe and reliable function of a firearm.

To configure the headspacing on the Urutau or other FGC-style firearm, we will use a jig to ensure a proper fit. Please utilize the jig included with the firearm you would like to create. The following instructions will explain how to use the Urutau's headspacing jig.

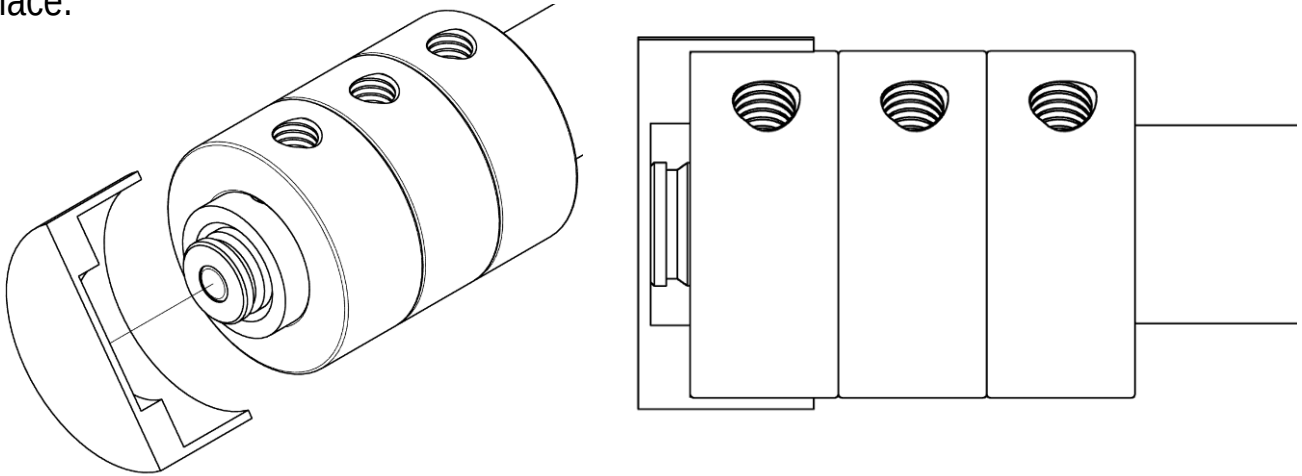
1. Insert a 9x19mm Luger cartridge into the chamber.



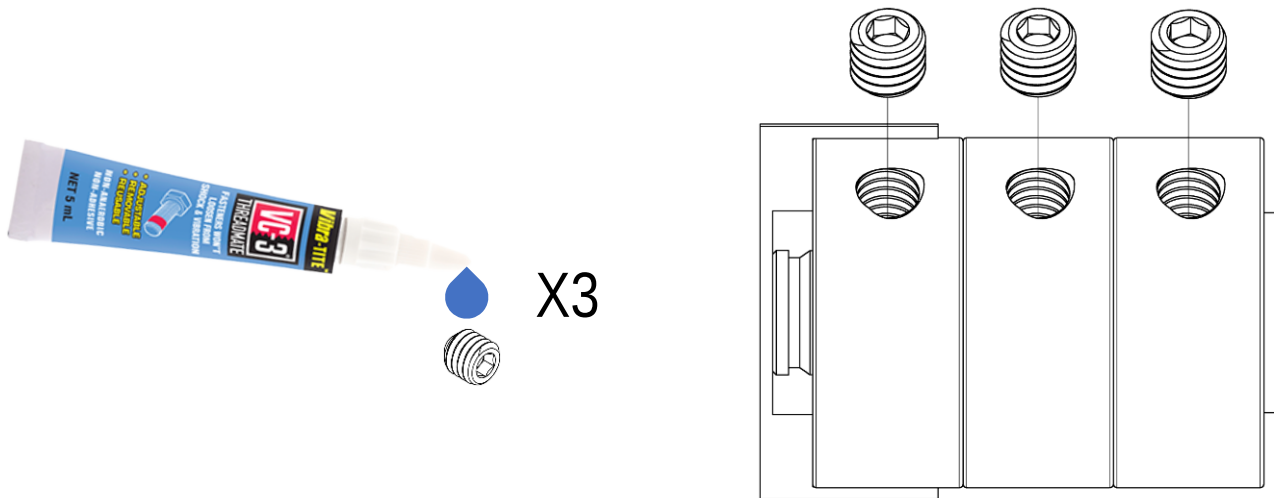
2. Remove the retention screws from the shaft collars and set them aside. They are likely too long, and you will need to use the 6mm-long M6 DIN 914 retention screws in step 4. Insert the barrel into the shaft collars and hold them around the chamber.



3. Apply the headspacing gauge as depicted. Wherever the case head is flush with the surface of the jig will determine where you will want to tighten the shaft collars in place.



4. Apply a drop of threadlocker to the three 6mm-long M6 DIN 914 set screws and use them to secure the shaft collars down. Tighten them as hard as you can.



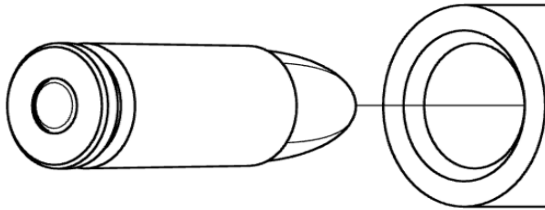
5. Check the jig one more time, as you did in step 3, to make sure that the shaft collars did not move when tightening them down. It is critical that your headspacing is perfect before the threadlocker cures. After that point, removing the shaft collars may require taking destructive measures, as depicted.



# CHAMBER HONING

The purpose of this process is to ensure that casings are able to eject themselves as smoothly as possible. This step is not a hard requirement, but it may enhance the reliability of your firearm.

1. Insert a 9x19mm Luger cartridge into the chamber.



2. Hold your barrel with the chamber pointing to the ground. If gravity causes the cartridge to fall out, you do not need to hone your chamber. If not, remove the cartridge and proceed to step 3.

3. Measure the first 16mm of your flex hone brush from the tip down. Apply a piece of masking tape with the edge at the 16mm mark. This is for reference to avoid honing too deep.



4. Apply the flex hone brush to a drill and insert the brush up to the edge of the masking tape. Do not go any deeper. If you go deeper, you may ruin your chamber.



5. Hold the barrel and drill steady and spin the flex hone brush for a few seconds. Clear out the debris with a cotton patch and some oil. Try the experiment in steps 1 and 2 again. If gravity causes the cartridge to fall out, you are finished. If not, repeat steps 4 and 5 until it does.